L HUMBOLT COUNTY
SOLID WASTE RESOURCE
RECOVERY STUDY
1977

APPENDIX I

PLANT DESCRIPTION

HUMBOLDT COUNTY

SOLID WASTE RESOURCE RECOVERY STUDY

ANALYSIS OF FUEL, ASH, AND FLUE GAS CHARACTERISTICS

ASH AND LEACHATE ANALYSIS

EAST HAMILTON
SOLID WASTE REDUCTION UNIT

HAMILTON, ONTARIO, CANADA

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ANALYSIS OF FUEL, ASH AND FLUE GAS CHARACTERISTICS

SUMMARY

This report presents the results of an operational test recently completed at the Solid Waste Reduction Unit in Hamilton, Ontario, Canada. The purpose of the test was to gather information on the environmental impacts associated with the operation of the processed solid waste incineration facility in Hamilton. This information can be used to flag areas needing additional attention in the design of new facilities.

The facility at Hamilton is designed to handle 600 tons per day of municipal refuse. The refuse is shredded to a 6-inch minus fuel, conveyed past a ferrous metals recovery system, and delivered to two 105,700 pound per hour steam boilers. The boilers are of water-tube design, with water-walls, a travelling grate, and spreader stokers. The plant was designed to generate for industrial process use. However, at present the only use for the steam is to drive auxiliary equipment in the plant. The majority of the steam produced is run through surface condensers on the roof and returned as feedwater.

Each boiler is fitted with a two-stage electrostatic precipitator. The precipitators are designed to remove 98.5 percent of particulate emissions from the boilers.

The test was conducted under the overall supervision of CH2M HILL and Winzler & Kelly, both consulting engineers, under contract with Humbolt County, California. Other participants included EPA Region X; Environment Canada; Ontario Ministry of Environment; Babcock and Wilcox; Alsid, Snowden, and Associates; and Ontario Research Foundations. Several pre-test conferences and site surveys were held to coordinate the activities during the week of the test.

The test was performed from 12 through 18 October 1976. Operating difficulties, mainly with fuel feed and overfire air, restricted the available time for sampling. These difficulties plagued the plant during the whole week, making it difficult to maintain the steady steam load conditions desired. All of the scheduled tests were completed, however some were not at the planned steam load conditions or in the number of replications desired. Samples were taken of the refuse fuel; the flue gas emissions, both gasious and particulates; and the ash. Fuel gas emissions were effected by the unsteady operation of the boiler.

The analytical phase included determining the composition and heating value of the fuel, analyzing the concentrations of gaseous and particulate flue gas emissions, determining the composition of the ash, and running a leachate analysis on the ash. The results of the analyses, performed by several of the participants in the test, are consolidated and presented in this report.

The particulate emissions corrected to 1290 CO_2 stack ranged from 0.536 grains per dry standard cubic foot at 44 percent load to 0.81 grains per dry standard cubic foot at 70 percent load. The efficiency of the electrostatic precipitator was estimated at about 90 percent. The results of a resistivity measurement on the particulate were in the range where good performance would be expected from a precipitator. However, this unit was operating at higher than design air flow and dust loading, which, coupled with some maintenance problems contributed to its inefficient performance. Particulate carryover to the precipitator inlet was greater than normally would be expected from a more stable steam load operation. Visible opacity from the stack was significant, relating to the particulate emissions.

Gaseous emissions were mostly in the normal range to be expected from refuse firing. Sulfur oxide and chloride emissions were greater than other comparable data from the literature. However, analysis of the refuse showed greater than normal sulfur and chloride content. The refuse composition will vary considerably depending on the geographical location and the time of the year. Emissions of oxides of nitrogen, hydrocarbons, total carbonyls, and organic acids were affected by the non-stable boiler operation.

Several areas of the operation of a processed refuse fired incinerator-heat recovery plant should receive further attention in the design of future facilities. These include handling, storage, and feeding of the refuse, protection of instrumentation and auxiliary equipment from dust generated, design of the boiler combustion chamber for the firing of this light fuel, and the collection of the fly ash generated.

ASH AND LEACHATE ANALYSIS

SUMMARY

Chemical analyses were performed on ash generated by a municipal incinerator in Hamilton, Ontario, Canada, under varying conditions, in order to determine the constituents of the ash and the potential for movement of these constituents in the environment. Analyses were performed 1) on the ash itself, 2) on a filtered water extract subjected to a three-day contact period with the ash, and 3) on leachate produced under simulated landfill and rainfall conditions. Results of the analyses show that a number of the ash constituents are readily soluble and may be leached in fairly high concentrations. As would be expected, the solubility of a number of constituents appeared to be pH-dependent. Many constituents were leached more readily and in higher concentrations from the composite ash column (pH~ 12), whereas others, especially heavy metals, were more readily leached from the modified landfill columns (pH~ 4-6). The low pH values of the soil-ash-soil columns are attributed to the acidic properties of the soils utilized.

A strict interpretation of results cannot be made due to the non-homogeneity of the ash sample and the simulation of rainfall and landfill conditions in the laboratory. The results of the analyses do show, however, that a number of constituents of concern can potentially be leached from incinerator residues, and that the ultimate disposal of residues should be carefully examined. Due to the quantity of ash anticipated to result from the present project, it appears that disposal of incinerator ash in a properly constructed Class II-1 site may be appropriate.

INTRODUCTION

The test conducted on the Solid Waste Reduction Unit at Hamilton, Ontario, Canada, is a portion of a larger solid waste energy recovery study being conducted for Humboldt County, California. The feasibility of utilizing the solid waste from the greater Eureka, California area for the generation of useful energy is being determined. Emissions to the air, water and land from solid waste energy recovery facilities can be significant, and without proper design considerations may prohibit a facility from operating within regulatory agency limits on emissions. Energy recovery from solid waste is still a relatively new technology with numerous theoretical studies and reports but very few practical tests on operating facilities. Before proceeding into predesign studies on any energy recovery concept, the County of Humboldt, with the concurrence of the State of California, authorized its contractors, CH2M HILL of Portland, Oregon, and Winzler and Kelly of Eureka, California, to gather as much of this data as practical. The data would then be disseminated for use in other projects in California and elsewhere. The purpose of the test was to gather data on the existing facility, not to determine compliance with existing regulations.

The Solid Waste Reduction Unit in Hamilton, Ontario is the only continuously operating water-walled incineration facility in North America using processed raw solid waste as the primary fuel. For this reason, the Hamilton facility was selected and a comprehensive test program was organized. As the test plans evolved, several equipment manufacturers and governmental agencies became interested, and contributed interest, advice, and funds to the project.

This report documents the description of the facility, development of the test, the test coordination, the on-site testing, and the analytical results of tests performed on the refuse, flue gas, ash, and leachate from the ash.

PLANT DESCRIPTION

The East Hamilton Solid Waste Reduction Unit is a facility which was designed to reduce the volume of the municipal solid waste from the municipality of Hamiltonn-Wentworth in Ontario, Canada to produce steam. The plant has been operational since 1972. The steam which is generated in the water-tube boilers during the incineration of the refuse is presently used only for driving mechanical-drive turbines in the plant. The majority of the steam is piped to surface condensers on the roof where the heat is transferred to the atmosphere. There is no present requirement to maintain a continuous steam load output from the boilers.

The refuse is pulverized and delivered to the boilers on a conveyor system. Ferrous metals are removed ahead of the boilers for recycling. A pulverized fuel storage bin, originally included in the system, has been bypassed due to operating problems. The boiler plant contains two Babcock & Wilcox, Canada Stirling boilers, each with a capacity of 105,700 pounds per hour, 250 psig steam. The boilers are of the spreader stoker design, with a traveling grate, similar to units designed for coal and hogged wood.

An electrostatic precipitator is installed on each boiler to remove particulates emitted with the flue gas. Each precipitator is a two-stage unit, designed for 98.5 percent efficiency, based on an inlet loading of 2.8 grains per standard cubic foot. The flue gas is pulled through the precipitators by induced draft fans and discharged to the atmosphere from a 175-foot high stack.

The remaining ash, consisting of bottom ash, siftings, and fly ash from the precipitators is disposed of as landfill adjacent to the plant. A detailed plant description is included in Appendix 1.

TEST DEVELOPMENT

During September of 1976, data relative to the physical and chemical composition of potential air emissions and ash from the incineration of solid waste as published in technical literature was reviewed. Areas needing further test data or confirmation of previous results were noted and various parameters needing development for air emissions, ash, leachate and raw solid waste were identified. This information was then listed along with a proposed sampling method and analytical technique, specific to the physical arrangement at Hamilton. Sample times and sizes of samples needed for later laboratory analysis were also listed.

This preliminary listing of test procedures was then circulated to various governmental agencies having responsibility for setting or enforcing standards on the proposed Humboldt County energy recovery facility, along with the major air pollution control agencies in California. Comments on the proposed test methods or possible additional tests were solicited. Several meetings were also held to discuss the concerns of all the various agencies involved.

The first meeting between the contractors and the various agencies occurred on 18 August 1976 in Eureka, California. At this meeting specific concerns relative to the air, ash and solid waste sampling were discussed. Input on the preliminary sampling and test procedures was also taken.

Present at this meeting were:

Bill Hammond, Southern California A.P.C.D.

Larry Burch, California State Solid Waste Management Board

Army Palansky, California State Solid Waste Management Board

Chuck Sassenrath, Humboldt County A.P.C.D.

Guy Kulstad, County of Humboldt

Bill Kuntz, County of Humboldt

Brad Garretson, Garretson, Elmendort, Zinov, Reibin (GEZR)

Lamont Matthews, CH2M HILL

Wayne Hanson, CH2M HILL

Mike Kennedy, CH2M HILL

Duane Heber, Winzler and Kelly

The refuse sampling technique that was developed as a result of input from the pretest meetings, previous solid waste sampling projects and published literature is included in this report as Appendix 2. The forms that were used for recording the raw field data are also included as Appendix 3.

A similar meeting was held on 19 August 1976 in Berkeley, California to discuss methods of generating and testing leachate from the ash samples. The standard State of California water quality test for leachate was discussed and additional test requirements listed.

Those present at this meeting were:

Tom Dunbar, California Regional Water Quality Control Board

Jim Suhrer, California Department of Health

Bob Stevens, California Department of Health

Bill Kuntz, County of Humboldt

Mike Kennedy, CH2M HILL

Jerry Ficklin, Winzler and Kelly

Duane Heber, Winzler and Kelly

Once the specific details of the leachate test results were determined, a laboratory procedure was needed for standard leachate generation and analysis. To accomplish this and allocate responsibilities between CH2M HILL and Winzler and Kelly, a meeting was held in Portland, Oregon on 24 September 1976.

Those present at this meeting were:

Mike Kennedy, CH2M HILL

Al Grimm, Director, Solid Waste, CH2M HILL

Jerry Ficklin, Winzler and Kelly

The ash sampling method, the laboratory analysis of the ash composition, the leachate generation method and the leachate laboratory analysis method are included as Appendix 4. The actual number of leachate columns run in the laboratory will be determined during testing through consultation with County officials.

As a result of this pre-test preparation a final outline of tests, sample methods and analytical procedures was developed. Prior to the actual testing, approval of the procedures was obtained from representatives of the State of California Solid Waste Management Board; Los Angeles Air Pollution Control District and County of Humboldt. A copy of the final outline of test procedures is included as Appendix 5.

TEST COORDINATION

The fact that the Hamilton facility is located in Canada, plus the wide interest in the results of this test program, contributed to the large number of direct participants and interested agencies. The pre-test coordination of these groups necessary to insure a successful test was important and time consuming.

The participants in the Hamilton source test and their general areas of responsibility were:

Regional Municipality of Hamilton Wentworth

Providing the facility for testing and physical assistance in conducting the test.

Plant contact: Mr. H. Saunders, Chief Engineer

Ontario Ministry of the Environment and
Environment Canada

Will test air emissions after the electrostatic precipitator for selected contaminants (particulates, PCB and PNA). Test boiler and precipitator ash (PCB). Testing to be done by a private contractor.

Contact: Ontario Ministry of the Environment
Dino Mozzon, phone (416) 965-5776

Environment Canada
Gordon Rosenblatt, phone (416) 966-5850

Environmental Protection Agency

Will test air emissions after electrostatic precipitator (particulates, particle size, opacity, resistivity). Testing to be conducted by a private contractor to EPA, Alsid, Snowden, and Associates.

Contact: Tobie Hegdahl, phone (206) 442-1260

Ken Brooks, test supervision,
phone (206) 442-1260

Humboldt County, California

Comprehensive test of air emissions after electrostatic precipitator, boiler and precipitator ash, input fuel. Testing responsibility CH2M HILL/ Winzler & Kelly.

Contact: Wayne Hanson, coordination,
phone (503) 224-9190

Rick Reid, test supervision,
phone (503) 752-4271

Babcock and Wilcox

Test air emission prior to electrostatic precipitator and monitor boiler operating parameters during test.

Contact: Canada: Alex Topley, phone (519) 621-2130

USA: Robert Rockford, phone (216) 494-7610

To agree on areas of responsibility, operating plans for the boiler, sampling equipment installation and necessary facility modifications, several pre-test meetings were held. The first meeting was held on 25 August 1976 in Hamilton, Ontario. Those present at the meeting were:

Mr. H. Saunders, Chief Engineer, Regional Municipality of Hamilton-Wentworth

Robert Rockford, Babcock and Wilcox

Alex Topley, Babcock and Wilcox, Canada

Jim Young, Babcock and Wilcox, Canada

Carl Bozeka, Babcock and Wilcox

David Reschly, Detroit Stoker Company

Wayne Hanson, CH2M HILL

Subsequent to this meeting, a second meeting was held on 27 August 1976 in Hamilton to discuss the tests and test procedures with the Ministry of Environment, Ontario. Those present at this meeting were:

Wayne Hanson, CH2M HILL

Dino Mozzon, Ministry of Environment, Ontario

Hugh Campbell, Ministry of Environment, Ontario

Gordan Rosenblatt, Environment Canda

A final pre-test coordination meeting was held in Buffalo, New York on 29 September 1976. Those present at this meeting were:

Ken Brooks, Environmental Protection Agency

Dino Mozzon, Ministry of Environment, Ontario

Vlado Ozvacic, Ministry of Environment, Ontario

Dr. F. J. Hopton, Ontario Research Foundation

Alex Topley, Babcock and Wilcox, Canada

Carl Bozeka, Babcock and Wilcox

Rick Reid, CH2M HILL

Stan Witkowski, Babcock and Wilcox

Between formal meetings, the participants were in close telephone contact and all parties were kept aware of major developments and progress in planning. Several participants, including EPA, Babcock & Wilcox, and CH2M HILL made trips to Hamilton for preliminary surveys prior to the test. Operating problems were observed and discussed with plant personnel. The plant was shut down for two weeks prior to the test to make modifications to improve operating conditions. The plant was put back into operation the week prior to the test to work out any start-up problems with the modifications. This pre-test groundwork was accomplished to provide the basis for a successful test, with a minimum of confusion and duplication of efforts. Letters of appreciation have been sent to the participants in the testing.

TEST EXECUTION

Participants in the testing program arrived at Hamilton on Monday, 11 October 1976, to install sampling equipment and make final preparations for testing on Tuesday. Boiler operation began on Tuesday at 8:39 a.m. Almost immediately, operating problems restricted sampling. Due to various feed problems, a consistent load could not be held and no samples were collected. The air and fuel feed problems continued to restrict sampling time during the entire test run. Table 2 summarizes the potentially available sampling time and the actual time during which boiler operating conditions allowed useful samples to be taken. Only 23 percent of the potential sampling time was actually usable time. Appendix 6 includes a detailed operating log for each day indicating the specific problems during the test period.

Table 3 lists a majority of the operating problems which occurred during the test affecting the results obtained. The results of the tests should be a good indication of how the facility at Hamilton operates. The wide swings in boiler steam load, steam pressure, gas side temperatures, and flows created by the operating conditions listed made it difficult to obtain results which would be "typical" of a boiler operating at a condition requiring a stable steam load. A service representative from B&W was provided during the test in an attempt to operate the unit at steady state conditions, but the many problems listed in Table 3 precluded obtaining the operating conditions desired.

During the 5 operating days testing took place, a total of 500 tons of solid waste was fed to the boiler, 24.3 tons of ferrous metal was removed and 4.12 tons of non-ferrous material was picked from the solid waste before shredding. Table 4 summarizes the plant fuel input conditions on a daily basis.

During the sampling period, all of the desired tests were completed, although some of the samples were not collected in the desired number of repetitions and at the desired load level, due to the aforementioned fuel and air feed problems. Over 2,000 pounds of precipitator and boiler ash was collected for lab analysis, 22 solid waste composition samples were completed and solid waste samples were taken for laboratory analysis of heat content and chemical composition. The fact that all desired tests and samples were obtained was due in part to the excellent cooperation and assistance extended by the Hamilton-Wentworth plant operating personnel. Table 5 summarizes the samples that were collected and the conditions under which they were taken.

RESULTS

Refuse

Twenty-two samples taken from the incoming refuse were sorted to determine their composition. The results of this sampling are presented in Table 6. The percentage of each constituent varied from sample to sample. Comparing the sample mean to similar data published for other geographical areas indicates the percentage of paper and wood products to be low, the plastics, food and garden wastes to be high. The refuse delivered to this plant is almost 100 percent from residential sources. The plastics fraction is affected by the large number of garbage bags used for disposal of the refuse. The large amount of food and garden wastes relates to the test being run during the fall when plants are stripped from gardens, and during the week after Thanksgiving in Canada. October is also the wine making season for the residents of the area. Considerable quantities of grape vines were evident in the refuse.

Several density measurements were made on the refuse in the as-delivered state and after shredding. The densities as-delivered varied from 7.7 to 14.5 pounds per cubic foot, averaging 9.7 pounds per cubic foot. The moisture content of this material normally averages between 25 and 30 percent. Moisture content take on samples which were returned to the lab for analysis were much higher, running 45 to 50 percent. This discrepancy is due to decomposition of the sample during shipment to the lab, which took close to a month due to problems with the airlines. Densities measured on the shredded refuse delivered to the boiler were 2.5 to 3 pounds per cubic foot. However, this material has a tendency to pack in any container used to measure it. The density on the conveyors is probably closer to 2 pounds per cubic foot.

Table 2

SAMPLING TIME AVAILABLE
EAST HAMILTON SWARU TEST

Day	Daylight Hours Available	Actual Time During Which Boiler Load Conditions Allowed Stack Sampling Runs to be Made	Remarks
Tuesday 10/12/76	11	0	I.D. fan dampers stuck. Fuel feed chutes continued to plug.
Wednesday 10/13/76	11	5	Continued air and fuel feed problems.
Thursday 10/14/76	11	3	Same as above.
Friday 10/15/76	11	0	Replacement of bridge breaker drives and modifications to the pulleys took most of the day. Started having problem with overfire air turbine drive.
Saturday 10/16/76	11	3	Overfire air turbine drive malfunctioning. Finally replaced part of governor.
Sunday	11	2 1/2	Pulverizer plugged. Fuel feed problems continued.
Monday 10/18/76	11	4	Continued pulverizer and fuel feed problems.
TOTAL	77	17 1/2 (23%)	

Table 3

PLANT OPERATING CONDITIONS AFFECTING RESULTS
EAST HAMILTON SWARU TEST

Operating Condition		Reason
1.	Fuel Feed	
	A. Erratic overfire air supply	Turbine drive on overfire air fan malfunctioning
	B. Improper fuel spread on grate	Erratic overfire air supply Rotary drive on spreader inoperative Unequal fuel flow through each feed chute
	C. Nonuniform feed	Feed chute plugging No surge in feed system--directly connected to pulverizer feed Not varied automatically in proportion to steam load
	D. High feed rates	Heating value of fuel lower than design spec. No reinjection of fly ash
2.	Combustion Air	
	A. Poor I.D. fan control	Damper sticking Automatic controls inoperative
	B. Insufficient I.D. fan capacity	Part of damper welded closed
	C. Nonuniform fuel spread on grate	See previous comment
3.	Instrumentation and Control System	
	A. Many instruments not operational	Maintenance of instruments not emphasized
	B. Most controls not calibrated	Maintenance of instruments not emphasized
4.	Electrostatic Precipitator	
	A. Inefficient performance	Air leakage at discharge hopper openings Several warped collection plates Higher than design gas flows & dust loadings Partial blockage due to buildup on acess walkway

Table 4

FUEL AND ASH QUANTITIES
EAST HAMILTON SWARU TEST
OCTOBER 12 - 18, 1976

Date	Test Period	Refuse Fed To Pit Tons	Ferrous Metal Picked Tons	Non-Ferrous Picked Tons	Ferrous Metal Separated Tons	Net Fuel To Boiler Tons	Bottom Ash Tons	Fly Ash Tons	Total Ash Tons	Steam Produced M LBS
Wednesday 10/13/76	9:23 a.m. to 7:00 p.m.	166	0.5	1.0	6.2	158.3	17.7	3.9	21.6	627
Thursday 10/14/76	8:15 a.m. to 5:00 p.m.	70 (est.)	0.38	0.75	2.5	66.4	14.4	4.0	18.4	357
Friday 10/15/76	-	-	-	-	-	-	-	-	-	-
Saturday 10/16/76	8:20 a.m. to 5:50 p.m.	85 (est.)	1.0	0.6	3.9	79.5	19.8	5.9	25.7	478
Sunday 10/17/76	8:15 a.m. to 5:30 p.m.	100	0.75	0.9	4.6	93.8	19.9	6.6	26.5	410
Monday 10/18/76	9:00 a.m. to 4:00 p.m.	102	1.5	0.9	3.0	96.6	19.7	5.9	25.6	411
TOTAL		523	4.13	4.15	20.2	494.6	91.5	26.3	117.8	2283

SUMMARY OF SAMPLES COLLECTED
EAST HAMILTON WENTWORTH SWARU TEST
OCTOBER 11-18, 1976

Parameter	Sample Collected By	Samples Collected — Objectives	Samples Collected — Actual	Remarks
Stack Emissions				
Temperature, Gas Flow Moisture, & Particulate Discharge from Stack	EPA & ORF	EPA: 3 samples full load 3 samples part load ORF: 3 samples full load	EPA: 1 sample @ 83% 1 sample @ 50% 1 sample @ 44% ORF: 2 samples @ 70%	
Particulate Sizing Inlet Outlet	 B&W EPA	 5-6 samples 2 samples Brinks impactor	 3 samples at 60 to 80% load None - will size from filter catch on method 5 train	
Opacity	CH2M HILL	Samples during each particulate test plus random samples	Samples during each test plus 4 random samples	
Composition of Particulates	EPA	1 sample for spectrographic analysis	1 sample	
Resistivity	B&W	1 sample for analysis by EPA	1 sample	
CO, CO_2, O_2, N_2	EPA & B&W	EPA: integrated ORSAT - 6 tests B&W: grab ORSATS - 6 tests	EPA: integrated ORSAT 3 tests B&W: grab ORSATS - 3 tests	
SO_2	ORF	3 samples full load	3 samples @ 34-71% load	
NO_x	ORF	3 hours continuous at near full load	3 - 3 hour continuous samples at 46-62% average load.	
Chlorides	ORF	3 samples at near full load	3 samples at 56-74% load	

Total HC	ORF	3 hours continuous at near full load	3 - 3 hour continuous samples at 46-62% average load
PNA's	ORF	3 samples at near full load	1 sample at 70% load
PCB's	ORF	3 samples at near full load	1 sample at 70% load
Organic Acids	ORF	3 samples at near full load	3 samples at 44-55% load
Aldehyde, Total Carbonyls	ORF	3 samples at near full load	3 samples at 44-55% load
Mercury	ORF	3 samples at near full load	3 samples at 44-55% load
Carcinogenic Organics	ORF	3 samples at near full load	3 samples at 56-76% load
Fuel Samples			
Boiler Input	CH2M HILL	Compute daily during test periods	Daily during test periods
Physical Composition	CH2M HILL	As many samples as possible	22 samples
Densities	CH2M HILL	6 minimum on as delivered material, 3 on shredded material	10 samples as delivered 3 samples shredded
Samples for Lab Analysis	CH2M HILL	3 samples as delivered, 1 sample shredded	4 samples as delivered, 2 samples shredded
Ash Samples			
Boiler & Precip. Discharge	W&K	Weight & volume measurements during each sampling period	Same
Densities	W&K	3 samples daily	Same
Samples for Lab Analysis	W&K	Daily samples giving total of 3 - 55 gallon drums of ash. 10 gallons of precip. quench water	Same

Boiler Operation

Steam Load	B&W	Steam flow charts	Same
Steam Pressure	B&W	Recorder charts	Same
Steam Temperature	B&W	Test conditions	Saturated steam, not superheated
Grate Speed	B&W	Measure during tests	Same
E.S.P. Settings	B&W	Record during stack particulate tests	Same

TABLE 6

RESULTS REFUSE COMPOSITION SAMPLING
EAST HAMILTON SWARU

DATE LIVERED	SAMPLE NUMBER	SAMPLE WEIGHT LB.	CONTENT % ALL PAPER PRODUCTS WOOD PRODUCTS AND TEXTILES	PLASTICS	RUBBER AND LEATHER PRODUCTS	FOOD, GARDEN WASTES AND FINES	FERROUS METALS	NON-FERROUS METALS	GLASS	REMAINING INERTS	SOURCE
	13-1	1,312	43.9	4.6	0.4	38.9	3.8	0.8	5.5	2.1	
ONESDAY	13-2	217	53.6	8.6	0.7	17.8	5.1	0.6	10.6	3.0	Residential – some low
13/76	13-3	458	45.3	4.3	1.6	30.8	9.6	1.0	6.8	0.7	low income
	AVG.	662	47.6	5.8	0.9	29.1	6.2	0.8	7.6	1.9	
	14-1	298	62.3	3.4	0.6	13.5	10.1	0.3	5.4	4.4	
	14-2	420	52.0	6.0	0.2	19.0	17.1	0.6	4.6	0.5	
URSDAY	14-3	443	42.7	4.3	1.5	34.6	7.0	0.6	9.3	0.0	Residential and Commercial
14/76	14-4	299	27.3	2.7	0.9	56.4	4.0	0.3	8.4	0.1	
	16-1	489	43.1	4.2	0.6	34.3	5.2	0.7	10.1	1.7	
	16-2	260	46.2	6.2	1.2	29.8	6.2	0.6	5.2	4.8	
	AVG.	368	45.6	4.5	0.8	31.3	8.3	0.5	7.2	1.9	
	15-1	289	33.7	4.5	1.6	42.5	8.5	1.2	7.4	0.6	
	15-2	306	35.9	4.2	1.9	30.9	10.3	0.4	14.5	1.8	
DAY	15-3	336	32.3	3.7	0.2	54.2	3.6	0.2	5.1	0.6	Residential
15/76	15-4	354	40.0	10.9	0.3	23.3	9.5	1.5	11.7	2.9	
	15-5	359	37.7	3.8	0.9	42.7	7.3	0.4	7.1	0.2	
	16-3	271	44.6	4.8	1.4	34.5	7.6	0.4	5.3	1.4	
	17-1	250	50.6	3.8	0.6	29.4	5.8	0.9	8.6	0.3	
	17-2	350	35.3	5.0	0.1	37.6	8.6	0.9	11.0	1.6	
	17-3	300	60.0	3.7	0.7	21.8	6.3	0.5	6.2	0.9	
	AVG.	313	41.0	4.9	0.9	35.4	7.5	0.7	8.5	1.1	
	18-1	237	41.7	5.9	0.3	30.5	11.8	0.9	6.1	2.7	
	18-2	310	28.6	4.2	4.5	43.6	6.9	0.5	11.0	0.7	
NDAY	18-3	303	48.7	4.1	0.2	23.1	5.3	0.5	7.8	10.2	Residential - above
18/76	18-4	218	38.6	7.6	0	29.8	10.8	1.5	10.8	0.8	median income
	AVG.	267	39.5	5.5	1.3	31.8	8.7	0.9	8.9	3.6	
22 SAMPLE MEAN		367	42.9	5.0	0.9	32.7	7.7	0.7	8.1	1.9	Nearly 100% residential delivered by packer trucks in plastic garbage bags. Few aluminum cans.

TABLE 7

ESTIMATE HHV REFUSE FUEL
HAMILTON, SWARU

Component	HHV* BTU/LB	As Received %	As Received HHV, BTU/LB	To Boiler %	To Boiler HHV, BTU/LB
Food	1,800	14.0	252	15.2	274
Paper	6,600	35.0	2,310	37.9	2,501
Wood	7,800	5.2	406	5.6	437
Garden Waste	4,300	13.0	559	14.1	606
Textiles	6,400	2.7	173	2.9	186
Plastics and Rubber	18,000	5.9	1,062	6.4	1,152
Fines	2,000	5.7	114	6.2	124
Ferrous Metal	-300	7.7	-23	0	0
Non-Ferrous Metal	-300	0.7	-2	0.8	-2
Glass	-300	8.2	-24	8.8	-26
Inerts	-300	1.9	-6	2.1	-6
		100.0	4,821	100.0	5,246

The higher heating value of the processed refuse was estimated from the results of the composition analysis. The estimate is presented in Table 7. The heating value of each component is based on data presented in "Combustion Engineering", a book published by Combustion Engineering Inc. in 1966, and edited by Glenn R. Fryling. Estimates were made both on an as-received and to-boiler basis, the difference being the removal of the ferrous metals. The heating values are based on a nominal 25 percent moisture content for the refuse. The estimated heating values are based on a nominal 25 percent moisture content for the refuse. The estimated heating value of 5246 BTU per pound is 12.5 percent less than the 6000 BTU per pound used for design of the plant.

The total amount of refuse burned during each test day was measured as it was dumped into the storage pit ahead of the shredders. The quantities are listed in Table 4. The pounds of steam produced from this refuse, determined by integration of the steam flow chart, is also listed on Table 4. The pounds of steam produced per pound of refuse delivered to the plant varied from 1.9 on Wednesday to 2.8 on Saturday. The average for the six days of testing was 2.2 pounds of steam per pound of refuse delivered.

Three samples of the as-received refuse which were shipped to the laboratory were analyzed for chemical composition. The results of the proximate, ultimate, and ash analyses are presented in Table 8. These analyses were run on the combustible fraction of the refuse, which was about 82 percent of the total. The proximate analysis shows about a 12 percent ash content in the combustible fraction. Adding this to the 18 percent non-combustible fraction yields a total of 30 percent non-combustible of which 7.7 percent is ferrous metals.

The ultimate analysis indicates a fairly high sulfur content in the refuse. This is due to the high food and garden waste fraction in the samples. The compounds listed under quantitive were identified by either atomic absorbtion spectroscopy or wet chemical methods. Silicon and calcium oxides make up fifth percent of the ash.

The trace metal analysis, performed by atnomic absorbtion spectrophotometry, shows only very small amounts of trace metals which are of concern, such as lead, mercury and arsenic.

Flue Gas Emissions

The results of the flue gas testing and analysis are presented in Table 9. The results are a compilation of data from EPA Region X, Ontario Research Foundation, Babcock and Wilcox, CH2M HILL, and Winzler and Kelly. Reports developed by the first three organizations are included in Appendix 7.

TABLE 8

CHEMICAL COMPOSITION
AS-RECEIVED REFUSE

		SAMPLE 1	SAMPLE 3	SAMPLE 4	AVERAGE
PROXIMATE ANALYSIS (DRY BASIS)					
Volatile Matter,	%	72.4	78.7	75.0	75.4
Fixed Carbon,	%	15.0	11.7	11.4	12.7
Ash	%	12.6	9.6	13.6	11.9
ULTIMATE ANALYSIS (DRY BASIS)					
Carbon	%	39.6	36.8	36.9	37.7
Hydrogen	%	5.0	5.8	7.0	5.9
Nitrogen	%	1.3	0.7	1.3	1.1
Oxygen	%	45.3	51.1	44.6	47.0
Sulfur	%	0.3	0.24	0.28	0.27
ASH ANALYSIS (DRY BASIS)					
Quantitative					
SiO_2	%	36.0	35.1	26.8	32.6
CaO	%	17.6	14.7	20.3	17.5
Cl	%	6.4	7.6	10.6	8.2
Al_2O_2	%	4.4	11.2	5.8	7.1
P_2O_5	%	1.9	5.8	6.7	4.8
Fe_2O_3	%	3.0	3.6	7.0	4.5
K_2O	%	4.6	3.5	4.3	4.1
SO_3	%	4.1	2.6	4.5	3.7
MgO	%	4.7	3.3	2.7	3.6
Na_2O	%	2.9	2.8	2.9	2.9
TiO_2	%	1.8	2.2	1.1	1.7
Semi-Quantitative (Emission Spectroscopy)					
B_2O_3	%	0.05	0.07	0.85	0.32
ZnO	%	0.25	0.25	0.25	0.25
PbO	%	0.12	0.08	0.15	0.12
BaO	%	0.08	0.07	0.20	0.12
MnO	%	0.08	0.07	0.08	0.08
Cr_2O_3	%	0.03	0.07	0.01	0.04
CuO	%	0.05	0.03	0.05	0.04
SrO	%	0.03	0.02	0.04	0.03
ZrO_2	%	0.01	0.01	0.01	0.01
SnO_2	%	0.008	0.008	0.01	0.009
MoO_3	%	0.004	0.01	0.003	0.006
V_2O_5	%	0.004	0.01	0.003	0.006
P_2	%	<0.005	<0.005	<0.005	<0.005
NiO	%	0.004	0.003	0.004	0.004
Co_2O_3	%	0.001	0.003	0.001	0.002
Ga_2O_3	%	0.001	0.002	0.001	0.001
Ag_2O	%	<0.001	<0.001	<0.001	<0.001
TRACE METALS (DRY BASIS)					
(ATOMIC ABSORPTION SPECTROPHOTOMETRY)		%			
Zinc	ug/gram	.0527	541	557	542
Copper	ug/gram	0248	48.3	35.9	648 244
Lead	ug/gram	.0141	138	178	152
Manganese	ug/gram	.0100	78.7	103	93.9
Chromium	ug/gram	77.9	68.9	65.9	70.9
Nickel	ug/gram	62.4	57.5	84.1	68.0
				59.1	54.0

TABLE 9

RESULTS FLUE GAS ANALYSIS
EAST HAMILTON SOLID WASTE REDUCTION UNIT

A. STACK DISCHARGE PARTICULATE EMISSIONS

Test No.	1	2	3	4	5
Date	10/13/76	10/14/76	10/14/76	10/18/76	10/18/76
Time	1745-1930	1500-1615	1745-1915	1410-1703	1410-1703
Steam Load					
Range lb/hr	45,000-115,000	25,000-114,000	24,000-114,000	21,000-87,000	21,000-87,000
Average lb/hr	88,000	53,000	46,000	75,200	75,200
% Full Load	83	50	44	70	70
Steam Pressure, Average psig	220	215	200	220	220
Stack Temp. Average °F	487	498	487	554	554
Moisture, % V/V	17.3	14.1	10.8	12.5	12.5
CO_2, %	10.4	6.4	4.5	10.2	10.2
Opacity					
Average %	20	15	—	25	25
Range %	5-45	5-30	—	5-60	5-60
⩾ 40% Min./hr.	3	0	—	3.5	3.5
⩾ 20% Min./hr.	27.5	18.5	—	46	46
Gas Flow, Average,					
ACFM	97,700	91,650	95,000	102,500	102,500
dSCFM	44,300	43,000	46,300	39,500	39,500
lb/hr	228,800	215,800	228,800	200,000	200,000
Particulate Discharge					
Grains/dSCF	0.595	0.286	0.244	0.62	0.692
Grains/dSCF @ 12% CO_2	0.690	0.536	0.645	0.73	0.81
Grains/dSCF @ 6% O_2	0.740	0.570	0.634	0.81	0.90
lb/hr	230	105	97	210	235
lb/1,000 lb gas	1.00	0.50	0.43	1.05	1.17
Particle Sizing, Microns					
Mean	200	—	—	—	—
% < 100μ	30	—	—	—	—
Test by	EPA	EPA	EPA	ORF	ORF

A. STACK DISCHARGE PARTICULATE EMISSIONS (Cont'd.)

Composition %	
Potassium	8.25
Silicon	5.86*
Calcium	4.75
Sodium	4.15
Aluminum	3.40
Zinc	2.70
Iron	1.00
Lead	0.57
Titanium	0.43*
Magnesium	0.14
Cadmium	0.14
Manganese	0.12
Boron	0.011*
Tin	0.11
Copper	0.07
Nickel	0.067
Chromium	0.06
Mercury	0.03
Strontium	0.012*
Barium	0.005
Molybdenum	0.004*
Zirconium	0.003*
Antimony	0.003*
Bismuth	0.003*
Vanadium	0.002*
Cobalt	0.001*
Silver	0.001*
Gallium	0.001*
Arsenic	0.001
Phosphorus	–

*Semi-quantitative by emission spectrography

B. STACK OPACITY (at Nontest Periods)

Date	10/16/76	10/16/76	10/16/76	10/17/76	–
Time	0935-1005	1415-1445	1525-1555	1105-1135	–
Opacity,					
Average %	20	20	40	35	–
Range, %	5-35	5-45	15-80	15-70	–
≥ 40% Min./hr	0	0.5	34.5	19	–
≥ 20% Min./hr	35	45	56.5	57	–
Steam Load, Average					
lb/hr	60,000	75,000	81,000	84,000	–
% Full Load	57	71	77	79	–

TABLE 9

RESULTS FLUE GAS ANALYSIS
EAST HAMILTON SOLID WASTE REDUCTION UNIT

C. PRECIPITATOR INLET PARTICULATE LOADING (as measured)

Date	10/16/76	10/17/76	10/18/76	–	–
Time	1445-1700	1055-1300	1300-1445	–	–
System Load					
Range lb/hr	21,000-125,000	21,000-100,000	21,000-100,000	–	–
Average lb/hr	82,000	85,000	69,000	–	–
% Full Load	78	79	64	–	–
Steam Pressure, Average psig	225	220	223	–	–
Flue Gas Temp. Average °F	630	635	635	–	–
Moisture, % by Volume	13	13	13	–	–
CO_2, % by Volume	10.3	11.2	10.4	–	–
Gas Flow, Average,					
ACFM	145,900	143,800	131,000	–	–
dSCFM	58,900	58,100	53,000	–	–
lb/hr	265,000	260,000	239,000	–	–
Particulate Loading					
Grains/dSCF	0.96	1.01	1.93	–	–
lb/hr	421	413	722	–	–
lb/1,000 lb Gas	1.59	1.59	3.02	–	–
Particle Sizing, Microns (Anderson Cascade Impactor)					
% < 1u	5	5	8	–	–
% < 10u	10	15	25	–	–
Resistivity (10% Moisture) T= 550F	3.4×10^9	–	–	–	–
OHM-Centimeters 650F	9.2×10^8	–	–	–	–

D. PRECIPITATOR PERFORMANCE (Calculated from Collection Hopper Discharge)

Test No.	1	2	3	4	5
Steam Load, % Full Load	83	80	44	70	70
Flue Gas Temp °F	487	498	487	554	554
% CO_2	10.4	6.4	4.5	10.2	10.2
Particulate Concentration Grains/SCF @ 12% CO_2					
Inlet	6.52	6.57	7.64	6.04	6.80
Outlet	0.690	0.536	0.645	0.730	0.810
Particulate Loading lbs/1,000 lbs Flue Gas					
Inlet	9.46	6.12	5.10	8.69	9.82
Outlet	1.00	0.50	0.43	1.05	1.17
Particulate Discharge, lbs/hr					
Inlet	2170	1300	1165	1945	1960
Outlet	230	105	97	210	235
Collection Efficiency, % (estimated)	89.4	91.8	91.5	89.2	88.0

RESULTS FLUE GAS ANALYSIS
EAST HAMILTON SOLID WASTE REDUCTION UNIT

E. STACK DISCHARGE GASEOUS EMISSIONS

ORSAT Analysis						
Date	10/13/76	10/14/76	10/14/76	10/16/76	10/17/76	10/18.
Time	1745-1930	1500-1615	1745-1915	1400-1645	1035-1245	1245-17
Carbon Dioxide %	10.4	6.4	4.5	10.3	11.2	1
Oxygen %	9.0	13.5	15.2	9.5	8.5	
Carbon Monoxide, %	0	0	0	0	0	
Nitrogen, %	80.6	80.1	80.3	80.2	80.3	8
Steam Flow,						
Average lb/hr	88,000	53,000	46,000	78,000	84,000	75,(
% Full Load	83	50	44	74	78	

Sulfur Dioxide					
Date	10/16/76	10/16/76	10/16/76.	Average	—
Time	1048-1118	1327-1357	1412-1442	—	—
PPM (Vol)	114	206	236	185	—
lb/hr	45.9	82.9	94.8	74.6	—
Steam Flow,					
Average lb/hr	36,300	68,000	75,200	59,800	—
% Full Load	34	64	71	57	—

Oxides of Nitrogen, as NO_2					
Date	10/14/76	10/14/76	10/16/76	Average	—
Time	1000-1300	1415-1715	0920-1140	—	—
PPM (Vol.)					
Range	0-160	20-200	30-170	—	—
Average	110	125	100	110	—
lb/hr - Average	31.8	36.1	28.9	32.3	—
Steam Load,					
lb/hr Average	65,500	54,500	46,900	56,300	—
% Full Load	62	52	46	53	—

Chlorides					
Date	10/16/76	10/16/76	10/16/76	Average	—
Time	0938-1038	1327-1427	1502-1602	—	—
As Free Cl_2					
PPM	7.45	7.12	7.08	7.2	—
lb/hr	3.36	3.21	3.16	3.24	—
As HC					
PPM	251	259	240	250	—
lb/hr	57.5	59.4	55.0	57.3	—
Steam Load,					
lb/hr	59,700	71,600	78,200	69,800	—
% Full Load	56	68	74	66	—

TABLE 9

RESULTS FLUE GAS ANALYSIS
EAST HAMILTON SOLID WASTE REDUCTION UNIT

E. STACK DISCHARGE GASEOUS EMISSIONS (Cont'd.)

Total Hydrocarbons					
Date	10/14/76	10/14/76	10/16/76	Average	—
Time	1000-1300	1415-1715	0920-1140	—	—
PPM - Range	20-1250	20-700	40-1080	—	—
lb/hr Average	360	200	400	320	—
Steam Load,					
lb/hr	65,500	54,500	48,900	56,300	—
% Full Load	36.2	20.1	40.2	32.2	—
Organic Acids (as CH_3COOH)	62	52	46		53
Date	10/14/76	10/14/76	10/14/76	Average	—
Time	1410-1510	1555-1655	1745-1845	—	—
PPM (Vol.)	5.53	18.50	16.01	13.34	—
lb/hr	2.14	7.15	6.18	5.16	—
Steam Load					
lb/hr	53,500	58,500	46,600	52,900	—
% Load	50	55	44	50	—
Aldehydes — Total Carbonyls as Formaldehyde					
Date	10/14/76	10/14/76	10/14/76	Average	—
Time	1410-1510	1555-1655	1745-1845	—	—
PPM (Vol.)	12.95	15.90	21.00	16.62	—
PPM @ 6% O_2	26.00	31.93	54.60	37.50	—
lb/hr	2.49	3.04	4.04	3.19	—
Steam Load,					
lb/hr	53,500	58,500	46,600	52,900	—
% Load	50	55	44	50	—
Mercury					
Date	10/14/76	10/14/76	10/14/76	Average	—
Time	1410-1510	1555-1655	1745-1845	—	—
PPM (Gaseous Only)	0.015	0.016	0.027	0.019	—
lb/hr (Gaseous Only)	0.0187	0.0210	0.0346	0.024	—
Steam Load,					
lb/hr	53,500	58,500	46,600	52,900	—
% Load	50	55	44	50	—

RESULTS FLUE GAS ANALYSIS
EAST HAMILTON SOLID WASTE REDUCTION UNIT

E. STACK DISCHARGE GASEOUS EMISSIONS (Cont'd.)

Polynuclear Hydrocarbons, (Benzopyrene)					
Date	10/18/76	–	–	–	–
Time	1410-1703	–	–	–	–
PPM (Vol.)	None Detectable	–	–	–	–
Steam Load,					
lb/hr	75,200	–	–	–	–
% Full Load	70	–	–	–	–
Polychlorinated Biphenols (PCBS) (as an Aroclor)					
Date	10/18/76	–	–	–	–
Time	1410-1703	–	–	–	–
lb/hr	0.01	–	–	–	–
Steam Load,					
lb/hr	75,200	–	–	–	–
% Full Load	70	–	–	–	–
Carcinogenic Organics					
Date	10/16/76	10/16/76	10/16/76		–
Time	1535-1605	1615-1645	1650-1720		–
Mutation Response	Negative	Positive	Negative		
Steam Load					
lb/hr	81,200	81,200	59,100		–
% Full Load	76	76	56		–

The nonsteady-state operating conditions which existed during testing had a significant effect on the flue gas emissions. This was especially true for the particulates, oxides of nitrogen, total hydrocarbons, total carbonyls and organic acids. The wide swings in fuel feed and steam generation affected furnace operating temperatures and combustion efficiencies. Since the formation of oxides of nitrogen and the oxidation of total hydrocarbons, total carbonyls and organic acids are all time and temperature dependent, the load swings and operating temperature variations yielded a wide range of results. Particulate emissions at the boiler outlet were probably higher than would normally be expected due to the surges in fuel and gas flows creating high velocities and particulate carryover from the furnace.

The results obtained during these tests are not a true indication of the capabilities of the equipment installed at Hamilton. Although it was not possible to stabilize the boiler operation to obtain steady-state conditions the results obtained from these tests are significant. Analysis of the results points out areas which must receive further attention in the design of future facilities.

Stack Discharge Particulate Emissions. The results of the particulate discharge measurements are presented first. Tests 4 and 5 were run concurrently by Ontario Research Foundation. Results were obtained for boiler operating conditions from 44 to 83 percent of full load. At each average load condition, a wide range of steam flows was experienced, due mainly to uneven fuel feed and air control. The gas flow at the stack did not vary proportionally with steam load, as might be expected. This was due to the condition of the I.D. fan dampers, previously discussed, which resulted in the dampers being in the wide open position most of the time. This also explains the low CO_2 readings at lower loads.

Visible opacity readings made during the particulate tests showed an average of 15 to 25 percent. The opacity was in excess of 20 percent up to 75 percent of the time during Tests 4 and 5. The highly visible emissions would be expected at the particulate concentrations measured.

Particulate concentration results were all of the same magnitude. Grain loadings, corrected to 12 percent CO_2, varied from 0.536 to 0.81 grains per dry standard cubic foot. These results are attributable to the unstable operating conditions and to overloading of the electrostatic precipitator. The precipitator loading will be discussed later. The inability to obtain a uniform fuel feed and proper distribution of the fuel on the grate undoubtedly

resulted in a greater than design solid particulate carryover from the combustion chamber. With an uneven spread of fuel on the grates, underfire air will concentrate and keep a large portion of the light fuel in suspension, allowing it to be carried out of the combustion chamber before complete combustion has occurred.

Particle sizing was accomplished by sieving a sample collected on a filter in the EPA sampling train. The mean particle size, on a weight basis, was 200 microns. This relates to the particulate concentrations present.

The sample collected on a second EPA filter was analyzed for composition of metals. A semi-quantitative analysis was made with an emission spectrograph. Several elements were then analyzed by atomic absorption spectrophotometry to obtain a more accurate quantitative measurement. The total metals content was about 32 percent of the total sample on the filter.

Stack Opacity (Non-test periods). Additional visible emission measurements were made on the days when stack particulate tests were not being run. The results of these measurements showed average opacity as high as 40 percent with peaks as high as 80 percent. These results are consistent with the particulate discharges. Visible emissions did increase with increasing boiler load.

Precipitator Inlet Particulate Loading (As measured). Three tests were completed by the Babcock and Wilcox testing team at the boiler outlet. Sampling conditions at this location were less than desirable. The duct area is quite large and the flue gas velocities very low, less than 800 feet per minute. The low velocities defy accurate measurement by a Pitot tube, and require large sampling nozzles for iso-kinetic sampling at a reasonable sampling rate. Interference from boiler and air heater tubes created disturbance upstream of the sampling nozzle. The large material being carried over to the precipitator was too big to enter the 3/8-inch sampling nozzle used.

All of the factors discussed above had some effect on the results obtained. Tests were made from 64 to 79 percent of rated load. The particulate loading results are not as high as would be expected. The maximum loading measured was only 56 percent of the inlet loading used for the precipitator design. The particle sizing, using the Anderson impactor, reports only particulate less than 10 microns in size. A considerable amount of small material was present. However, this could be skewed if the very large carryover material was not collected.

The resistivity measurements, made on one of the samples taken at the boiler outlet, are less than 10^{10} ohm - centimeters. The resistivity of the particles is in the range where normally efficient collection can be accomplished by electrostatic precipitation. References indicate resistivities below 10^6 and above 2×10^{10} can adversely affect electrostatic collection efficiency. It should be pointed out that the measurements were made in a laboratory and were not "in situ." The two methods can give different results.

Precipitator Performance. The fly ash collected and discharged from the precipitator hoppers was measured for each sampling day. The results of the measurements were compared to the total steam production for the period which was integrated from an enlarged copy of the steam flow chart using a planimeter. The average result was 23 pounds of ash collected per thousand pounds of steam produced. Using this result and the integrated steam flow during each sampling period for stack particulate emissions, the inlet loadings and performance of the precipitator were estimated. The results of these estimates were considerably higher than the results of the sampling in the boiler breeching. Grain loadings as high as 7.64 grains/dscf corrected to 12 percent CO_2 were estimated. Fly ash loadings were as high as 9.82 pounds per thousand pounds of flue gas. The fly ash loading did vary with steam load. The estimated fly ash discharge rate from the boiler to the precipitator is plotted against steam load in Figure 1. The relationship appears to be linear. The curve would normally be expected to be more hyperbolic, since gas velocities in the boiler normally increase with load. However, in these tests the flue gas flow was at a maximum during most test conditions. Therefore, the straight-line relationship between steam load, or fuel feed, and particulate discharge could be expected. Projection of the line to 100 percent load would result in a prediction of nearly 2,800 pounds per hour of particulate, which at the maximum air flow experienced would result in an outlet concentration of almost 12 pounds per thousand pounds of gas.

Based on the computations discussed above, the efficiency of the electrostatic precipitator averaged about 90 percent. It should be noted, however, that the precipitator was operating at 120 percent of the design flue gas flow and at 150 percent of the design inlet loading. Inspection by the manufacturer after testing indicated plate warpage and plugging in the first stage which could result in up to 20 percent loss in effective collection area.

Stack Discharge Gaseous Emissions. The results of gaseous emission analyses are presented in Section E of Table 9. Orsat analyses were taken as continuous samples at the stack on 13 and 14 October and as grab samples every 15 minutes at

the boiler outlet on 16 October through 18 October. The carbon dioxide and oxygen contents relate to steam load and the condition of constant induced-draft fan damper settings.

Sulfur dioxide emissions increased with steam load, as would be expected. The concentration in the flue gas also increased, but this was again due to the relatively constant flue gas flows. SO_2 emissions were due to the average fuel sulfur content of 0.27 percent, which is over twice as high as average data at other locations.

The oxides of nitrogen emissions were sampled with a continuous monitor. The NO_2 concentrations varied proportionally with steam load fluctuations. An overlay of the steam flowchart and the recorder trace for NO_x is shown in Figure 2. The boiler operated at close to 100 percent load from 1120 to 1125. The NO_x concentration during this period was about 115 ppm. NO_x peaks were observed to 200 ppm. Average NO_x concentrations were 100 to 125 ppm.

The majority of the chloride emissions were measured as HCl. The chloride discharges are consistent with the high chloride content of the fuel, which was up to one percent. The chlorides are constituents of the high percentage of plastics, over 6 percent, in the boiler fuel feed.

The total hydrocarbon emissions were measured continuously during three, three-hour periods. The range and average results are given in Table 9. A typical overlay of the steam flow chart and the recorder trace for THC is shown in Figure 3. Spikes to 1200 ppm are evident, which appear to occur at the start of fuel feed to the furnace, before furnace temperatures build up to oxidize the compounds to carbon dioxide. Emissions averaged from 100 to 200 ppm, during the sampling period. Unstable combustion conditions related to the total hydrocarbon emissions.

Organic acid and total carbonyl emissions are both affected by combustion conditions. System design to maintain high combustion temperatures and adequate residence time is imperative to insure efficient oxidation of hydrocarbon compounds.

Emissions of mercury were low. The average result for mercury in the gas phase was 0.024 pounds per hour at 50 percent load. The quantitative analysis of collected particulate shows it to be .03 percent mercury, which would result in another 0.03 pounds per hour of particulate mercury at 50 percent load. Mercury emission rate would increase with steam load, resulting in an estimate of a 0.11 pounds per hour total mercury at 100 percent load.

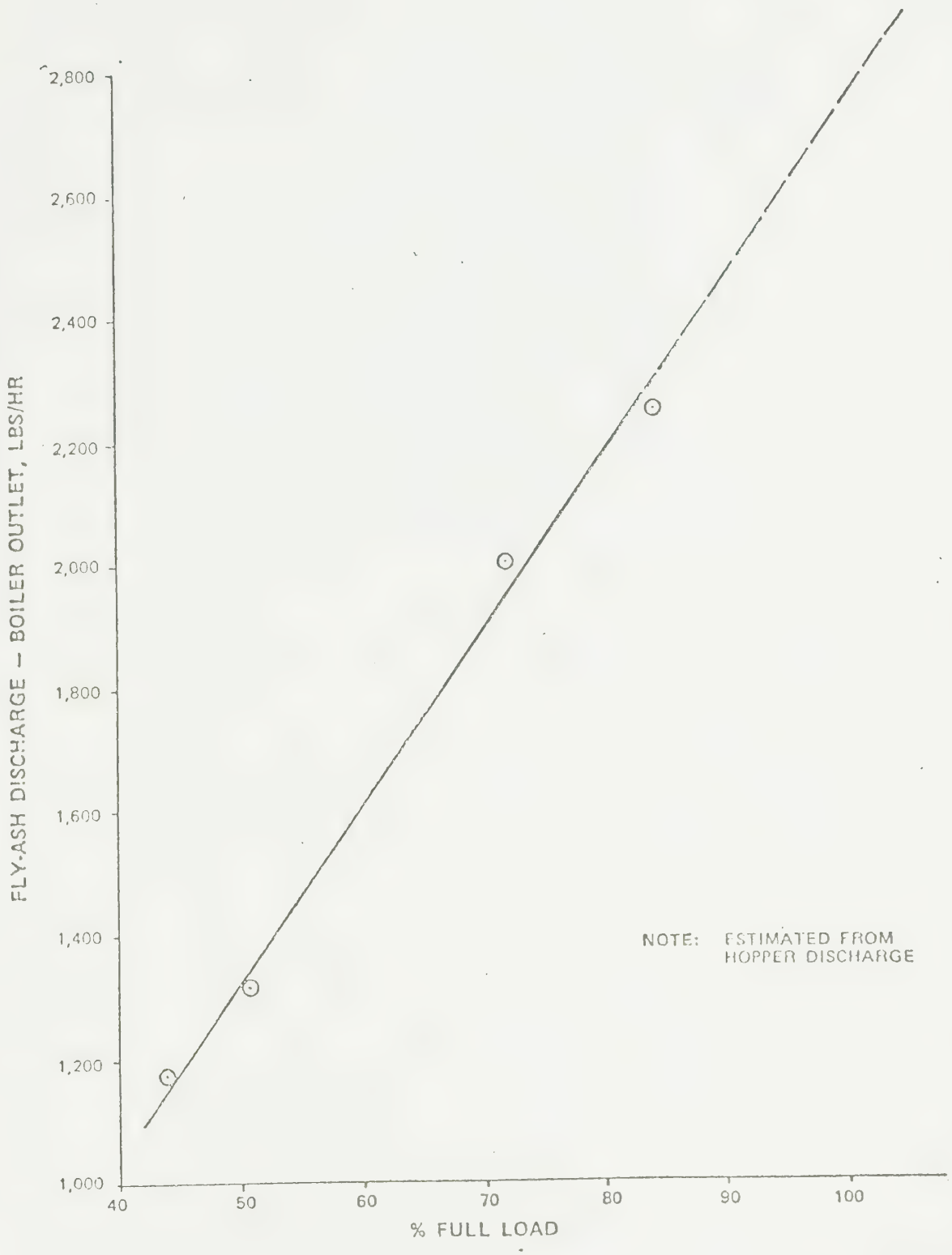

FIGURE 1

FLY-ASH DISCHARGE
BOILER OUTLET BREECHING VS STEAM LOAD

10/14/76

CH2M HILL

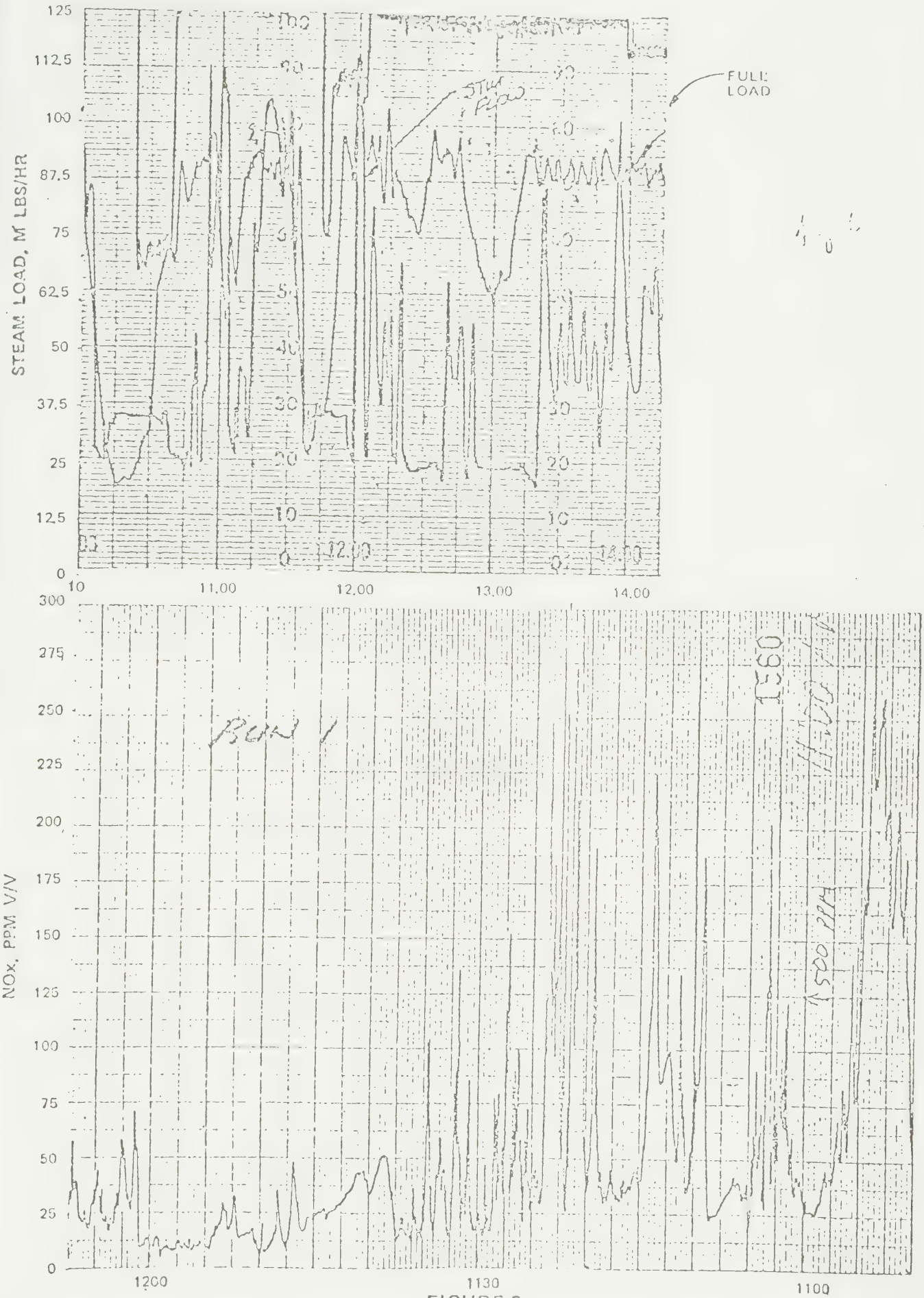

FIGURE 2
COMPARISON OF NOx EMISSIONS TO

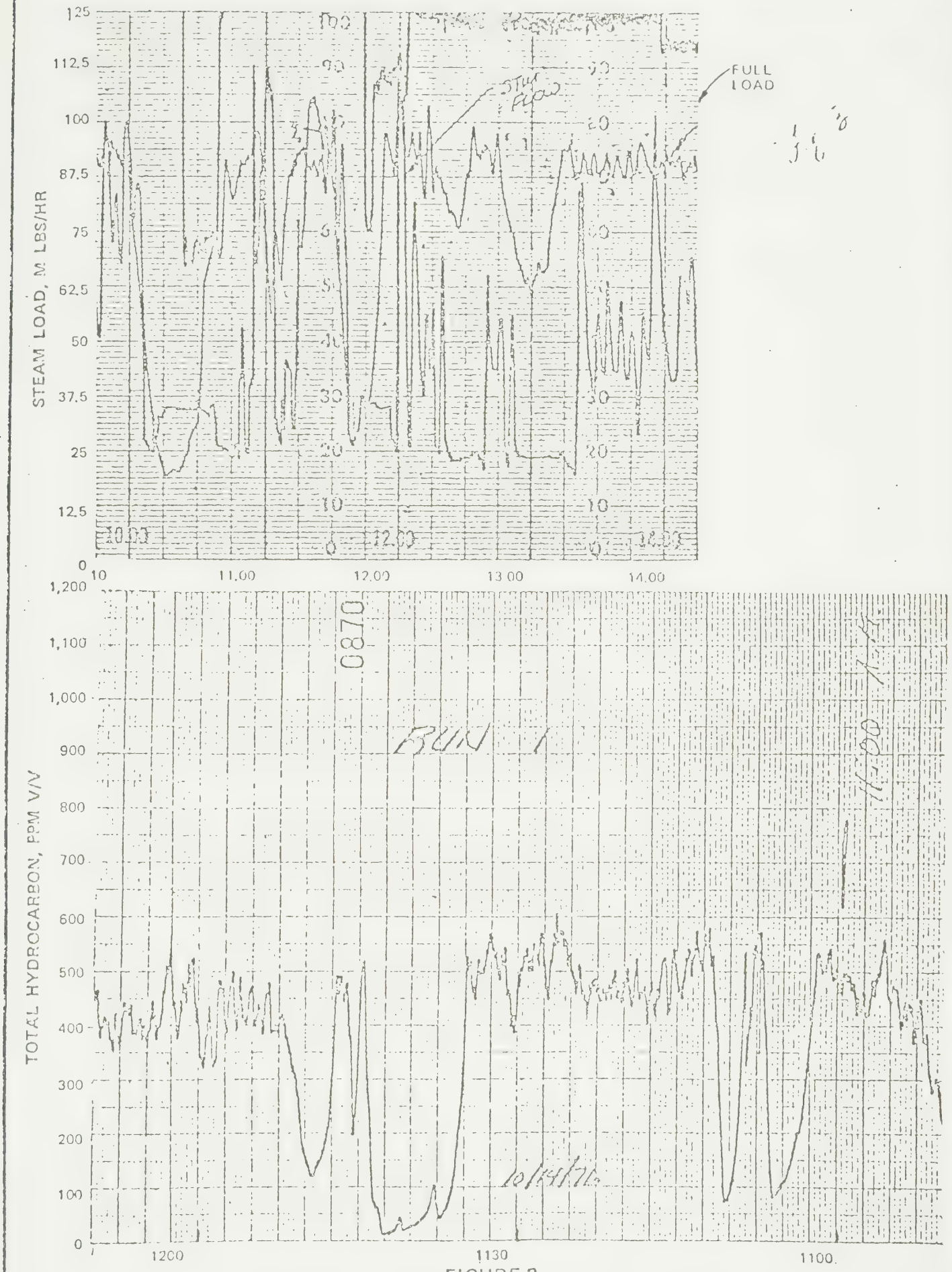

FIGURE 3

COMPARISON OF TOTAL HYDROCARBON EMISSIONS TO STEAM LOAD

CH2M HILL

particulate and gaseous samples taken on 18 October were analyzed for polynuclear hydrocarbons (PAH) and polychlorinated biphenols (PCB's). No PAH was detectable either in the gaseous or particulate form. A small amount of PCB's was found. However, the analytical laboratory, Ontario Research Foundation, is skeptical of the results for both of these compounds and recommends further testing.

Samples were taken to measure the potential for the emissions to form mutor bacteria, a form of carcinogenic growth. Due to handling and shipping delays, only qualitative analysis could be completed. Positive mutagenic potential was measured for only the second sample. Significant growth of mutox bacteria was not evident in Samples 1 & 3.

CONCLUSIONS

The performance of the plant during the testing period and the results of the tests indicate several areas of the operation which should receive further attention in the design of future plants of this type. Improvements in several areas should allow this type of facility to operate consistently at design load conditions without creating an undue burden on the environment.

The handling and feeding of the processed refuse is a critical item. This material is light, about 2 pounds per cubic foot, necessitating large conveyors and feed openings to handle the necessary volume. The material has an angle of repose of 90 degrees, bridging at almost any protrusion in the handling system. Consideration should be given to splitting the refuse feed into separate streams for each boiler feed opening ahead of the boiler. Use of the existing swing distributor does not appear practical.

A surge bin for the storage of processed fuel should be provided to allow a controlled volume of fuel to be fed to the boiler. A steady fuel feed is necessary to the production of a constant steam load. Fuel feed rate should be controlled automatically to maintain steam load and pressure. Processed fuel should not be stored in deep lifts or for more than several hours. Packing and decomposition will occur, which will create difficulties in recovery of the fuel from the bin.

Provisions should be provided for protection of the instrumentation, control, and auxiliary systems from the dust which is generated during the processing and handling of the refuse. All susceptible equipment should be located in dust proof enclosures. Considerable maintenance could be avoided by this measure.

The design of the boiler itself should be re-evaluated. A reduction in the amount of carryover which was experienced during this test should be possible through modifications to the combustion chamber. Consideration should be given to preheating the overfire air. Electric motor drives should be provided for all critical auxiliary equipment.

Evaluation of the stack gas particulate control equipment should be made. The high carryover of large material suggests the use of a precleaner ahead of a fine particulate collection device. Handling of collected flyash should be such that re-entrainment is minimized.

TEST RESULTS
ASH AND LEACHATE ANALYSES
HAMILTON, ONTARIO, MUNICIPAL INCINERATOR RESIDUE
HUMBOLDT COUNTY
SOLID WASTE RESOURCE RECOVERY STUDY

1. Introduction. An ancillary question to the Humboldt County, Solid Waste Resource Recovery Study of the feasibility for using a refuse derived fuel as an energy source is the disposal of the incinerated residue. Essentially, the incineration of municipal residue concentrates many of the parameters which may be of concern in water quality considerations. Landfilling, the only practical method for disposal of quantities of incinerator residue, exposes the material to rainfall, which, when percolating through the landfilled residue, leaches out various parameters that are then available for the contamination of state waters. Because of these potential problems, the state of California has designated community incinerator residue as a Group I waste which is a waste that consists of, or contains, toxic substances which could significantly impair the quality of usable waters. Due to the paucity of data on the leachate derived from municipal incinerator residues, this study was undertaken in an attempt to define parameters which may be expected to be contained in such leachate; to determine the significance of such parameters; and to determine if the leachate characteristics justify its classification as a Group I waste. Conclusions as to the significance and justification of a Group I classification will be withheld until the data in this study has been reviewed by an assemblage of experts convened by the State for the purpose of aiding in the derivation of those conclusions.

The generation of energy utilizing municipal refuse derived fuel, at this point in time, is a rarity. As a matter of fact, there is only one full scale steam generating complex utilizing municipal refuse derived fuel as its sole energy source in operation. Ash from this plant, located at Hamilton, Ontario, Canada, was used in this study in order for the results to be as representative of any proposed system as possible.

2. Study Methods. Three ash samples were collected during the week of 10 October 1976 from the Hamilton, Ontario incinerator. While the original intention was to collect a daily composite fly and grate ash sample, due to the sporadic firing schedule of the incinerator it was only possible to obtain two composite grate ash samples and one composite fly ash sample. The grate ash samples consisted of composites collected during the incinerator operations on the 13th and 15th of October, sample number, 11085817 and on the 16th and 17th of October, sample number, 11085818. The fly ash sample was composited over both grate ash sampling periods. The ash analysis was performed upon each of

the individual samples and upon a composited ash sample. The composite ash sample consisted of equal parts, by weight, of the two grate ash samples and a two to one mix, by weight, of the grate ash to fly ash (2 grate ash: 1 fly ash). The ash composited in this fashion was used in the leachate columns, composite ash water extraction, and chlorinated hydrocarbon analyses. The 2 to 1 mix was based upon ash production measurements conducted at the Hamilton incinerator plant during the sampling period.

3. Ash Sample Analysis. To avoid interferences and loss of parameters of interest, several digestion methods were used. The primary digestion method consisted of a nitric acid digestion. The insoluble material was further subjected to a hydrofluoric acid digestion followed by a final nitric acid digestion. The digested materials were then combined and dissolved in an aqueous solution upon which the analyses were performed. The mercury analyses were accomplished by cold-vapor techniques following a sulfuric-nitric acid and permanganate digestion. As it was thought that silica losses may have occurred during the primary digestion, a separate low temperature hydrofluoric acid digestion was conducted prior to determining silicon. Chloride and fluoride were determined upon the distillate collected after a sulfuric acid distillation of the ash samples. Total sulfur was determined following a magnesium nitrate-nitric acid digestion. A soxhlet extraction of the samples using an ether-hexane solvent was conducted in order to extract the chlorinated hydrocarbons for analyses. Herbicides were eluted from the ash sample through an elevated pH - hot water extraction. The elutriate was then extracted following normal herbicide procedures. Following the extraction or digestion procedures, analyses were performed in accordance with either Standard Methods for the Examination of Water and Wastewater, 14th edition; Methods for Analytical Analysis of Water and Wastes, MDQARL, NERC, EPA, Cincinnati, Ohio, 1974; or Methods for Organic Pesticides in Water and Wastewater, NERC, EPA, 1971. The analysis of sulfur was conducted in accordance with the procedure contained in "A Textbook of Soil Chemical Analysis," P. R. Hesse, Chemical Publishing Company, Inc., New York, 1972.

4. Ash Sample Results. Ash analyses were performed on each of the composite grate ash samples, the fly ash sample and upon a composited ash sample prepared as indicated above. Results of the ash analyses are as follows:

TABLE I
PARTICLE SIZE ANALYSIS

oratory Number	Fly Ash 11085816	Grate Ash 13,15 Oct 76 11085817	Grate Ash 16,17 Oct 76 11085818
ticle Size	Percent of Sample		
.1-50.8 mm		2	
.4-38.1 mm		3	3
.1-25.4 mm		2	5
.7-19.1 mm		8	6
52-12.7 mm	0.5	7	8
76-9.52 mm	0.5	23	22
38-4.76 mm	1	21	22
18-2.38 mm	2	15	20
60-1.18 mm	4	10	5
00-600 µm	15	5	4
50-300 µm	25	1	1
5-150 µm	17	1	1
75 µm	35	2	3

s indicated by the above analysis, the grate ash was not very omogeneous. It was apparent from visual observation of the ample that very little, if any ferrous and nonferrous metal eparation was being accomplished prior to incineration. The on-homogeneity is very evident from the results obtained on he following chemical analyses.

TABLE II

ASH ANALYSIS
(mg/kg-dry wt.)

aboratory Number	Fly Ash 11085816	Grate Ash 13,15 Oct 76 11085817	Grate Ash 16,17 Oct 76 11085818	Composite Ash Sample 11306300
arameter				
luminum	48,000	22,000	20,000	38,000
rsenic	4.0	3.8	3.4	2.0
arium	760	1400	780	860
admium	32	4	36	12
alcium	45,000	27,000	41,000	39,000
hloride	5400	1200	1100	2800
hromium	320	110	310	150
opper	270	24,000	1,700	3,800
luoride	60	14	16	21
ron	16,000	43,000	20,000	41,000
ead	600	540	400	560
agnesium	15,000	7,200	6,400	9,600
anganese	1800	660	640	1000
ercury	11.2	0.25	0.074	0.50
ickel	80	100	200	140
hosphorus (Total)	4500*	6300*	5200*	6200
otassium	25,000	10,000	6,800	9,800
elenium	104	88	62	110
ilicon	17,000	250,000	290,000	260,000
ilver	5.6	4.2	8.4	6.9
odium	66,000	30,000	34,000	48,000
in	96*	420*	52*	180*
itanium	3200	6200	1000	2100
inc	5200	3200	2000	3200
otal Sulfur	7500	2500	1600	2800
olatile Solids	130,000	16,000	16,000	----
ensity (lb/ft^3)**	76	74	70	----
usion Temp (°F)	2190-2300°	1600-2300°	1600-2300°	1600-2300°
esistivity Ohm-cm				
@ 80°F	1.6×10^7			
@ 450°F	1.4×10^8			
@ 600°F	1.1×10^7			
@ 750°F	2.9×10^7			

*Average of duplicate quality assurance samples
**As received at the laboratory

TABLE III
ASH ANALYSIS
Chlorinated Hydrocarbons
(mg/kg-dry wt.)

Laboratory Number	Composite Ash Sample 11306300
Parameter	
Aldrin	<0.1
BHC	<0.1
Chlordane	<0.1
DDD	<0.1
DDE	<0.1
DDT	<0.1
Dieldrin	<1.0
Endrin	<1.0
Endosulfan	<0.1
Heptachlor	<0.1
Heptachlor Epoxide	0.2
Lindane	<0.1
Methoxychlor	
Mirex	<1.0
PCB	<0.1
Strobane	<1.0
Toxaphene	
Dicamba (Banvel)	<0.05
2,4-D	<0.05
2,4,5-T	<0.05
2,4,5-TP (Silvex)	<0.05

Water Extraction Analyses. In this series of tests the ash samples were subjected to an extended water extraction, three days, and the analyses performed upon the water extract after having been filtered through 0.45 micron filters. Four separate extractions were performed as follows: two composite ash samples were extracted, one at a five grams per liter centration in buffered water and one at 40 grams per liter in nonbuffered water; each of the two grate ash samples were mixed with the fly ash and then extracted in a buffered distilled water solution at a concentration of 5 grams of ash per liter. Each of the extractions was mechanically stirred over the three day period at room temperature. No attempt was made to maintain a constant temperature; however, the temperature was continuously monitored over the test period and those records are available upon request. Analytical results for the water extracted ash samples are as follows:

TABLE IV
WATER EXTRACTABLE
Incinerator Ash Analysis
(mg/l)

...eter	Composite Ash Nonbuffered 40 g/l	Composite Ash Buffered 5 g/l	Grate/Fly Ash Buffered 13,15 Oct 76 5 g/l	Grate/Fly Ash Buffered 16,17 Oct 76 5 g/l
...ssay (LC_{50}, Rainbow Trout)	20%	**	**	**
...linity	130	150	190	170
...num	33	0.6	<0.1	<0.1
...nic	<0.02*	<0.02	<0.02	<0.02
...m	0.48	0.06	0.05	0.07
...emical Oxygen Demand	22	1.6	4.8	<1.5
...ium	<0.005	0.006	0.007	0.005
...ium	90	<1	<1	<1
...ride	93	13	16	23
...mium	0.01	<0.01	<0.01	<0.01
...ical Oxygen Demand	19	6	8*	9
...uctivity	810	***	***	***
...er	0.13	0.02	0.01	0.01
...ride	0.20	0.11	0.47	0.13
...rocarbons	<1	<1	<1	<1
...	<0.1	<0.1	<0.1	<0.1
...	<0.005	0.04	0.04	0.02
...esium	<0.2	13	18	16
...anese	<0.1	<0.1	0.32	<0.1
...ury	<0.001	<0.001	<0.001	<0.001
...el	<0.1	<0.1	<0.1	<0.1
...ate - N	<0.1*	<0.1*	<0.1	<0.1
...ite - N	0.13*	<0.01	<0.01	<0.01
	10.0	6.15	6.30	6.10
...phorus (Total)	<0.02	***	***	***
...ssium	51	***	***	***
...nium	<0.005	0.02	<0.005	<0.005
...con	<0.5	12	18	17
...er	<0.01	<0.01	<0.01	<0.01
...um	48	11	15	14
...ate	120	33	38	46
	<0.05	0.20	0.24	0.10
...nium	<0.1	<0.1	<0.1	<0.1
...l Dissolved Solids	550	***	***	***
	<0.04	0.17	0.12	0.08

...verage of duplicate quality assurance samples
...00% survival in 100% solution
...nalysis not performed due to interference from buffering solution

6. Modeled Leachate Analyses. In order to simulate landfill conditions as closely as possible, a series of columns were set up representing, at one-sixth scale, a section through a cell of landfilled municipal incinerator ash. The series of six inch diameter leachate columns consisted of:

a. Composite Ash Column. The two grate ash samples were composited together with the fly ash and compacted into the leachate column to a depth of 20 inches. The compacted density of the ash was 91.1 lbs/ft^3. The total weight of the ash was 29.8 pounds.

b. Soil Column, Site 4. The soil for this column was obtained from a cutbank in a clearcut timber harvested area located between the cities of Eureka and Arcata. The soil is mapped as being of the Larabee series[1] which has the following characteristics:

Depth Range:	40-70 inches
Color of Surface Soil:	Grayish brown
Color of Subsoil:	Strong brown
Reaction of Surface Soil:	Slightly Acid
Reaction of Subsoil:	Strongly acid
Texture of Surface Soil:	Loam
Texture of Subsoil:	Clay-loam
Parent Material:	Soft Conglomerate

The soil was compacted to a depth of twelve inches and density of 100.8 lbs/ft^3. The total weight of soil used was 19.8 lbs.

c. Soil Column, Site 8. The soil for this column was obtained from a cutbank just off the City Garbage sanitary landfill property. The soil is mapped as being a Hely-Larabee complex: The Larabee soil characteristics are as listed above and the Hely characteristics are as follows:

Depth Range:	40-70 inches
Color of Surface Soil:	Dark brown
Color of Subsoil:	Brown
Reaction of Surface Soil:	Slightly acid
Reaction of Subsoil:	Strongly acid
Texture of Surface Soil	Loam
Texture of Subsoil:	Fine sandy loam
Parent Material:	Soft sedimentary rock

The soil was compacted to a depth of twelve inches and a density of 103.9 pounds per cubic foot. The total weight of soil used was 20.4 pounds.

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[1]McLaughlin, J. and Harradine, F., November, 1965. Soils of Western Humboldt County, California. Department of Soil and Plant Nutrition, University of California, Davis and the County of Humboldt, California.

d. Soil-Ash-Soil Columns. These columns were constructed with two six-inch layers of soil bracketing a twenty-inch layer of composited ash. Two columns were constructed, one for each of the two soil types. The weights and densities of the soils and ash used were the same as for the ash and soil control columns.

Modeled annual amounts of rainfall were applied to each column and the resulting leachate collected for analysis. The simulated rainfall was glass distilled water which was passed through a mixed resin ion exchange column to ensure removal of all trace metals. The modeled annual precipitation amounted to 3.9 liters. After adding the simulated rainfall, the daily leachate production was measured, and when the leachate production was essentially complete, another year's simulated rainfall was added to the column. Each column received three years of simulated rainfall. Results of the modeled leachate analysis are as follows:

TABLE V
CONTROL COLUMN
Larabee Soil, Site 4

Leachate Analysis
(mg/l)

Parameter	1st year	2nd year	3rd year
Alkalinity	46	27	25
Aluminum	0.4	4.5	0.2
Arsenic	<0.02	<0.02*	<0.02
Barium	0.03	<0.01	<0.01
Biochemical Oxygen Demand	5.7	1.8	<1.5
Cadmium	<0.005	<0.005	<0.005
Calcium	4.3	2.3	2.2
Chloride	130	47	10
Chromium	<0.01	<0.01	<0.01
Chemical Oxygen Demand	13	4	1
Conductivity	570	230	100
Copper	<0.01	<0.01	<0.01
Fluoride	0.65	0.27	0.12
Hydrocarbons	----	<1	<1
Iron	<0.1	<0.1	<0.1
Lead	<0.005	0.005	<0.005
Magnesium	2.1	0.6	0.6
Manganese	<0.1	<0.1	<0.1
Mercury	0.001	0.004	0.006
Nickel	<0.1	<0.1	<0.1
Nitrate - N	0.48	0.24*	<0.1
Nitrite - N	0.01	<0.01	<0.01
pH	7.40	6.90	6.80
Phosphorus (Total)	0.48	0.37	0.18
Potassium	6.3	3.2	2.3
Selenium	<0.005	<0.005	<0.005
Silicon	11	9.9	8.2
Silver	<0.01	<0.01	<0.01
Sodium	110	42	18
Sulfate	9	2	9
Tin	<0.05	<0.05	<0.05
Titanium	<0.1	<0.1	<0.1
Total Dissolved Solids	330	140	70*
Zinc	<0.04	<0.04	<0.04
Leachate Volume (liter)	2.2	3.8	3.9

*Average of duplicate quality assurance samples

TABLE VI
CONTROL COLUMN
Hely-Larabee Soil, Site 8

Parameter	Leachate Analysis (mg/l) 1st year	2nd year	3rd year
Alkalinity	<1	<1	39
Aluminum	2.6*	1.8*	1.6*
Arsenic	<0.02	<0.02	<0.02
Barium	0.02	0.07	0.04
Biochemical Oxygen Demand	200	150	21
Cadmium	<0.005	<0.005	<0.005
Calcium	17	19	6.3
Chloride	74	76	6.4
Chromium	0.04	0.04	0.03
Chemical Oxygen Demand	410	380	140
Conductivity	550	560	190
Copper	0.07	0.06	0.03
Fluoride	1.4*	1.6*	0.57
Hydrocarbons	<1	1.2	<1
Iron	0.5	0.7	0.5
Lead	0.005	<0.005	<0.005
Magnesium	21	20	4.8
Manganese	0.75	1.3	0.40
Mercury	0.003	0.010	0.002
Nickel	0.3	<0.1	<0.1
Nitrate - N	0.16	0.11*	<0.1
Nitrite - N	<0.01	<0.01	<0.01
pH	4.65	4.60	6.20
Phosphorus (Total)	0.34	0.24	0.22
Potassium	14	13	5.1
Selenium	<0.005	<0.005	<0.005
Silicon	26	34	25
Silver	<0.01	<0.01	<0.01
Sodium	57	56	27
Sulfate	9	11	19*
Tin	<0.05	<0.05	<0.05
Titanium	<0.1	<0.1	<0.1
Total Dissolved Solids	540	560	240
Zinc	0.38	0.54	0.23
Leachate Volume (liters)	3.2	3.8	3.8

*Average of duplicate quality assurance analysis

TABLE VII
CONTROL COLUMN
Ash Composite

Leachate Analysis
(mg/l)

Parameter	1st year	2nd year	3rd year
Alkalinity	1800	1600	1100
Aluminum	2.5	2.5	3.0
Arsenic	0.21	<0.02	<0.02
Barium	1.3*	1.7	2.0
Biochemical Oxygen Demand	890	430	140
Cadmium	0.015	<0.005	<0.005
Calcium	540	450	360
Chloride	4200	1700	400
Chromium	<0.01	<0.01	<0.01
Chemical Oxygen Demand	1100	610	230
Conductivity	20,000	12,000	6,000
Copper	2.8	1.5	0.23
Fluoride	3.0	2.1	1.6
Hydrocarbons	<1	<1	<1
Iron	<0.1	<0.1	<0.1
Lead	0.09	0.01	0.18
Magnesium	1.8	<0.2	<0.2
Manganese	<0.1	<0.1	<0.1
Mercury	<0.001	<0.001	0.003
Nickel	0.2	0.2	<0.1
Nitrate - N	0.28	0.18	<0.1
Nitrite - N	0.13*	0.03	0.02
pH	12.20	12.30	12.40
Phosphorous (Total)	0.41*	0.17	0.04
Potassium	1900	930	430
Selenium	0.46	0.030	0.025
Silicon	1.4	1.0*	1.5
Silver	0.05	0.04	0.03
Sodium	2000	940	270
Sulfate	140	37	6
Tin	2.0	0.1	<0.05
Titanium	<0.1	<0.1	<0.1
Total Dissolved Solids	11,000	5,100	2,100*
Zinc	0.05	<0.04	<0.04
Leachate Volume (liter)	3.7	3.9	4.1

*Result of duplicate quality assurance samples

TABLE VIII
MODELED LANDFILL COLUMN
Soil-Ash-Soil
Larabee Soil, Site 4 - Composite Ash Sample

Parameter	Leachate Analysis (mg/l) 1st year	2nd year	3rd year
Alkalinity	54	<1	<1
Aluminum	5.0	70	3.0
Arsenic	0.14	0.17	<0.02
Barium	3.0	1.6	0.22
Biochemical Oxygen Demand	200	690	340
Cadmium	0.27	0.12	0.005
Calcium	170	200	15
Chloride	3500	2500	260*
Chromium	0.01	0.02	<0.01
Chemical Oxygen Demand	480	1300	550
Conductivity	11,000	9,800	2,500
Copper	0.02	0.07	0.02
Fluoride	3.3	3.2	0.62
Hydrocarbons	<1	<1	<1
Iron	0.45	2.9	0.35
Lead	0.09	0.07	<0.005
Magnesium	270	15	1.2
Manganese	12	7.9	1.0
Mercury	0.002	<0.001	<0.001
Nickel	0.4	0.2	<0.1
Nitrate - N	<0.1	<0.1	<0.1
Nitrite - N	0.96	0.01	0.01
pH	6.50	4.45	4.80
Phosphorus (Total)	0.35*	0.13	0.18*
Potassium	66	770	470
Selenium	0.20	0.24	0.044
Silicon	16	34*	12
Silver	<0.01	<0.01	<0.01
Sodium	1800	1400	270
Sulfate	67	1100	550
Tin	0.60	0.45	0.18
Titanium	<0.1	<0.1	<0.1
Total Dissolved Solids	6500	6900	1700*
Zinc	0.15	0.31	<0.04
Leachate Volume	2.82	3.3	3.9

*Average of duplicate quality assurance samples

7. Discussion of Results. Any interpretation of the results of this study, other than a very cursory discussion, will not be made until a panel of State experts have had a chance to review and comment upon the data. In reviewing the foregoing data, it must be borne in mind that it was our intent to show the worst possible case. For example, to facilitate leaching and extensive water contact with the ash, the leachate columns were set up at only 80 percent of the optimum compaction. Additionally, the entire modeled annual rainfall was applied to the columns and the columns fitted with evaporative shields to prevent loss of the applied simulated rainfall. No allowances were made for the water losses which will occur at an actual landfill site, such as runoff, evaporation and transpiration. It should also be noted that while the 50 inches of annual rainfall chosen as the modeled rainfall amount is reasonable for the two locations involved, other locations within the immediate area could receive annual rainfall amounts varying from as little as 30 inches to as high as 80 inches, due to the orographic effect of local terrain on rainfall patterns. In an attempt to minimize these effects the following tables report the leachate constituents as a percentage of the total material available to be leached. The values for the total material available to be leached were obtained by converting from the concentration values obtained in the ash analysis reported on a milligram per kilogram dry weight basis to the total ash contained in the leachate columns on a wet weight basis. The total material leached was obtained simply by multiplying the concentration of the leachate by the volume of leachate recovered. Several factors should be borne in mind when analyzing the percentage figures thus generated. First, it was assumed that the ash analysis was valid for determining the amount of material available to be leached. This may not be a valid assumption for all parameters due to the non-homogeneity of the ash sample. For example, the values obtained for copper in the two grate ash samples indicate considerable variation. Also, the assumption was made that the leachate concentration obtained for the control soil columns could be subtracted directly from the concentrations obtained from the soil-ash-soil columns, which may or may not be a valid assumption. For most parameters the background values obtained from the soil columns were negligible; however, the background values for mercury for Site 8 were higher in the second and third years, than for the soil-ash-soil column. Keeping in mind the foregoing precautions, the leachability of the parameters analyzed can be ranked as follows:

Parameters	Average Percent Leached* of material available
Chloride	76.0
Fluoride	14
Potassium	5.1

Parameters	Average Percent Leached * of Material Available
Arsenic	4.8
Sodium	2.4
Magnesium	0.7090
Mercury	0.6916
Cadmium	0.6162
Manganese	0.4601
Calcium	0.3996
Tin	0.2200
Aluminum	0.1692
Selenium	0.1443
Barium	0.1170
Nickel	0.0846
Chromium	0.0274
Silver	0.0252
Iron	0.0074
Silicon	0.0058
Lead	0.0055
Phosphorous - Zinc	0.0030
Copper	0.0006
Titanium	0

*In order to rank the parameters, the above percentages and those shown on the following tables were expressed to four places. The four places shown are not significant for any other purposes.

The following tables present the data generated for the ash column and each of the soil-ash-soil columns expressed as percentages of the amount of material available to be leached.

TABLE X
COMPOSITE ASH SAMPLE

Percent of Available Material Leached

Parameter	Materials Available in Ash (mg)	1st year	2nd year	3rd year	Total
pH		12.20	12.30	12.40	
Aluminum	349600	0.0026	0.0028	0.0035	0.0089
Arsenic	18.4	4.223	0	0	4.223
Barium	7912	0.0608	0.0838	0.1036	0.2482
Cadmium	110.4	0.0503	-0-	-0-	0.0503
Calcium	358800	0.5569	0.4891	0.4114	1.457
Chloride	25760	60.33	25.74	6.366	92.44
Chromium	1380	-0-	-0-	-0-	-0-
Copper	34960	0.0296	0.0167	0.0027	0.0490
Fluoride	193.2	5.745	4.239	3.395	13.38
Iron	377200	-0-	-0-	-0-	-0-
Lead	5152	0.0065	0.0008	0.0143	0.0216
Magnesium	88320	0.0075	-0-	-0-	0.0075
Manganese	9200	-0-	-0-	-0-	-0-
Mercury	4.6	-0-	-0-	0.2674	0.2675
Nickel	1288	0.0575	0.0606	-0-	0.1181
Phosphorus	57040	0.0027	0.0012	0.0003	0.0042
Potassium	90160	7.797	4.023	1.955	13.78
Selenium	1012	0.1682	0.0116	0.0101	0.1899
Silicon	2392000	0.0002	0.0002	0.0003	0.0007
Silver	63.48	0.2914	0.2457	0.1938	0.7309
Sodium	441600	1.676	0.8302	0.2507	2.757
Tin	1656	0.4469	0.0236	-0-	0.4705
Titanium	19320	-0-	-0-	-0-	-0-
Zinc	29440	0.0006	-0-	-0-	0.0006

TABLE XI
MODELED LANDFILL COLUMN
Soil-Ash-Soil
Larabee Soil, Site 4 - Composite Ash Sample

Parameter	Material Available in Ash (mg)	Percent of Available Material Leached			
		1st year	2nd year	3rd year	Total
pH	----	6.5	4.45	4.80	----
Aluminum	349600	0.0037	0.0618	0.0031	0.0686
Arsenic	18.4	2.146	3.049	-0-	5.195
Barium	7912	0.1059	0.0667	0.0108	0.1834
Cadmium	110.4	0.6897	0.3587	0.0177	1.066
Calcium	358800	0.1302	0.1818	0.0139	0.3259
Chloride	25760	36.89	31.42	3.785	72.10
Chromium	1380	0.0020	0.0048	-0-	0.0068
Copper	34960	0.0002	0.0007	0.0002	0.0011
Fluoride	193.2	3.868	5.005	1.009	9.882
Iron	377200	0.0003	0.0025	0.0004	0.0032
Lead	5152	0.0049	0.0042	-0-	0.0091
Magnesium	88320	0.8854	0.0538	0.0026	0.9118
Manganese	9200	0.3678	0.2834	0.0424	0.6936
Mercury	4.6	0.0613	-0-	-0-	0.0613
Nickel	1288	0.0876	0.0512	-0-	0.1388
Phosphorus	57040	0.0017	0.0008	0.0012	0.0037
Potassium	90160	0.1867	2.807	2.023	5.017
Selenium	1012	0.0557	0.0783	0.0170	0.1510
Silicon	2392000	0.0006	0.0033	0.0006	0.0045
Silver	63.48	-0-	-0-	-0-	-0-
Sodium	441600	1.079	1.015	0.2226	2.317
Tin	1656	0.1022	0.0897	0.0424	0.2343
Titanium	19320	-0-	-0-	-0-	-0-
Zinc	29440	0.0014	0.0035	-0-	0.0049

TABLE XII
MODELED LANDFILL COLUMN
Soil-Ash-Soil
Hely-Larabee Soil, Site 8 - Composite Ash Sample

Parameter	Material Available in Ash (mg)	Percent of Available Material Leached			
		1st year	2nd year	3rd year	Total
pH	----	4.00	4.00	4.80	----
Aluminum	349600	0.1532	0.1095	0.0070	0.2697
Arsenic	18.4	2.435	1.908	-0-	4.343
Barium	7912	0.0206	0.0227	0.0072	0.0505
Cadmium	110.4	0.1275	0.0389	-0-	0.1664
Calcium	358800	0.2970	0.1533	0.0209	0.4712
Chloride	25760	43.80	32.16	4.036	80.00
Chromium	1380	0.0255	0.0226	-0-	0.0481
Copper	34960	0.0001	0.0001	-0-	0.0002
Fluoride	193.2	14.58	4.037	-0-	18.62
Iron	377200	0.0029	0.0045	0.0015	0.0089
Lead	5152	0.0011	0.0008	-0-	0.0019
Magnesium	88320	0.4674	0.0353	0.0034	0.5061
Manganese	9200	0.1930	0.0212	0.0124	0.2266
Mercury	4.6	1.322	-0-	-0-	1.322
Nickel	1288	-0-	0.0303	-0-	0.0303
Phosphorous	57040	0.0003	0.0010	0.0011	0.0024
Potassium	90160	0.6602	3.101	1.496	5.257
Selenium	1012	0.0569	0.0694	0.0113	0.1376
Silicon	2392000	0.0016	-0-	-0-	0.0016
Silver	63.48	0.0504	-0-	-0-	0.0504
Sodium	441600	1.191	1.099	0.2349	2.525
Tin	1656	0.0773	0.0824	0.0459	0.2056
Titanium	19320	-0-	-0-	-0-	-0-
Zinc	29440	0.0012	-0-	-0-	0.0012

PLANT DESCRIPTION

BUILDING

The East Hamilton Solid Waste Reduction Unit, designed in the late 1960's, built from 1970 to 1972 and started up in June 1972 is fully enclosed in a concrete and steel building, with the exception of the weight scales, the abandoned shredded fuel storage bin, the abandoned ash storage silo, the electrostatic precipitators, and the stack. Included in the building are the following:

Tipping Aprons
Refuse Storage Space
Conveyor Pit
Pulverizers
Feed Conveyors
Magnetic Separator
2-105,700 #/hr Boilers
Boiler Control Room
Ash Conveyor
Plant Control Room
Maintenance Shop
Emergency Generator
Office w/2-Private Offices
Coffee Room for Office
Large Conference Room
Entry Area w/Men's and Women's Restrooms
Large Locker and Shower Room
Employee Coffee Room
Janitor's Room
Rest Rooms (Each Floor)
Motor Control Centers
Air Compressors

PULVERIZING SYSTEM

The refuse is dumped from the cantilevered tipping apron into a pit measuring 90 ft. long x 40 ft. wide x 30 ft. deep. The pit was sized to hold one day's refuse or 600 tons. The pulverizer feed conveyors were installed with 15 hp motors, which were too small to operate the apron conveyors when the pit is full. Therefore, the pit is not normally loaded with more than 150 to 250 tons. There is also a problem of too much weight pushing the conveyors off their tracks.

There are 4 pulverizer feed conveyors, one for each pulverizer. These are apron type, with the overlapping feature to reduce leakage. Each conveyor covers 72 feet horizontal length in the bottom of the pit, then inclines at a 45 degree angle for 36 feet vertically to discharge in the pulverizer inlet

hopper. Each conveyor is 6 feet wide with side walls 4 feet high. Conveyor speed is adjustable from 0-15 ft/min. They were operated at 7-8 ft/min. during testing. A platform has been constructed at tipping floor elevation which allows workers to pick oversize material off the conveyor before it enters the inlet hopper.

The pulverizers are the vertical shaft type, made by Heil. The casings are 48-inch I.D. Each unit is driven at 1,800 rpm by a 200 hp motor through a belt drive. The feed openings to the shredders are quite small, about 24-inches square, which limits the material which can be shredded. Operators have to be considerably careful to prevent plugging the inlets to the pulverizers. The plant is experiencing considerable wear problems with hammers. Homemade hammers last no more than 24 hours. Hardened factory hammers are lasting about a week.

PULVERIZED FUEL CONVEYORS AND FUEL FEED

Shredded material from the pulverizers discharges to Conveyor No. 5, which is 4 feet wide and 80 feet long from the center of the pit. This conveyor runs under the magnetic separator at 300 ft/min. discharging to conveyor No. 6A. 6A is 4 feet wide and 60 feet long running at 350 ft./min. 6A discharges at right angles to conveyor 6C. A short belt feeder is located below the transfer point to recover material carried under 6A. Conveyor 6C is 4 feet wide by 122 feet long. It carries the fuel back toward the old Atlas bin at 300 ft./min. At the bin, the material is transferred to conveyor No. 8, which elevates it into the power house. No. 8 is 4 feet wide by 180 feet long, running at 200 ft./min. No. 8 drops on to No. 9, which delivers to Boiler No. 1. This is a 4 foot wide by 15 feet long conveyor, running at 120 ft./min.

Conveyor No. 9 discharges into a fuel distributor which oscillates back and forth, distributing fuel to 3 feed chutes, each 14 by 23 inches. This distribution system has been a real plug-up problem, especially where the 3 hoppers separate. Two bridge breakers, about 6-inch diameter, supplied by B&W, have been replaced with cylinders 18-inch diameter. However, when the bigger rotating breakers were installed, the opening to each feed chute was made the same size. Since the center chute gets fed twice for each feed to the outer chutes, the center chute needs to be smaller, to equalize the fuel spread on the grates as it was in the original design. Presently, too much fuel is being fed through the center chute.

The bridge breakers are conveyor like head pulleys, mounted inside the chutes. A 1/2 by 1/4 inch steel bar has been welded on the chute around the breaker to keep material from jamming between the pulley and the chute. However, fines make their way through the remaining opening and eventually plug the area between the pulley and the chute. The pulleys should have been carried through the chute walls and sealed with rubber.

The transit time from the pulverizer to the boiler is about 2 minutes. Refuse starting at the bottom of the incline in the pit with the apron conveyor operating at 7 feet per minute would take about 9 minutes to get through the sytem.

BOILERS

Two Babcock & Wilcox, Canada spreader-stoker type Stirling boilers are located in the plant. Each boiler is sized to burn 300 ton/day of refuse and produce a full steam load of 105,700 pounds per hour at 250 psig saturated. Fuel is fed to the boiler house on one conveyor, then split to two belt conveyors each feeding the fuel distributor above each boiler, as previously described. A complete description of the boilers follows. Changes which have been made since the boiler description was written include:

1. The motors driving the air control rotor on the wind-swept fuel feed ports have been removed.

2. The turbine drive on the overfire air fan will be replaced with an electric motor. Variable steam pressure conditions effect the operation of the turbine and thus the delivery of stoker and overfire air.

3. The cinder reinjection system has been revised to a steam eductor type, using header pressure to educt the cinders back into the combustion chamber.

4. The boiler grate ash and siftings removal system originally installed has been abandoned. The original system consisted of screw conveyors from each boiler feeding a vacuum pick-up pneumatic conveyor system to deliver the ash to a storage silo. This system did not work due to poor design and wire in the ash. This system has been replaced with a belt conveyor which delivers the material to a pile. No quenching is required.

5. The precipitator ash conveyor system has also been modified to include a quench tank and belt conveyor for delivery to an ash pile. This material is quite fine and was producing a dusting problem in the landfill. It was also necessary to provide a good seal on the precipitator hoppers since it is on the suction side of the I.D. fan.

Each boiler has two-37.5 x 10^6 BTU natural gas burners which are used to preheat the fire box and keep the heat up during fuel stopages.

The boilers are shut down for one week minimum every six months for maintenance. The grates are inspected. Cotter pins, bolts, and washers that hold the grate bars to the chain are replaced. Grate bars have not required replacement, but the track that the grate runs on has been replaced once. The gas burner boxes and refractory were rebuilt this year after four years operation. The refractory arch which covers the back of the grate was replaced this year.

DETAILED BOILER DESCRIPTION

Each boiler is a Babcock & Wilcox Canada Ltd. balanced draught single pass two drum Stirling baffleless boiler with water-cooled membraned furnace and vertical tubular air heater.

Each boiler is fitted with a Babcock-Detroit Rotograte stoker 12' -1 1/2" wide x 18'-8" shaft centers and two Babcock & Wilcox circular type multi-spud auxiliary gas burners.

The boilers are designed to generate 105,700 lbs. of steam per hour each when burning 50,000 lb. of refuse per hour, with an average heating value of 6,000 BTU per lb. and a ten percent moisture content. The refuse fuel is municipal garbage, shredded in pulverizers and all metal removed prior to injection into the furnace. The fuel is injected into the furnace through three windswept spouts in the furnace frontwall above the stoker. The lighter material burns in suspension while the heavier material falls to the stoker grade and burns there. The stoker grate is continuously moving and constantly discharges the ash into an ash hopper at and under the front of the boiler. The speed of the stoker grate can be adjusted to suit load and fuel conditions. The hot gases generated from the combustion of the fuel pass up the furnace through the generating bank where most of the steam is generated, through an air heater to preheat the combustion air, through an electrostatic precipitator to clean the flue gas and then to the stack through an induced draft fan.

The combustion air is supplied to the boiler - under grate when the stoker is in service and to the gas burners when auxiliary fuel is being fired - by means of a turbine driven forced draught fan. An electric motor drive is also fitted to the fan for use when no steam is available. This fan has a test block rating of 203,400 lbs. of air per hour at a static pressure of 10.6" water gauge and a temperature of 105°F.

The combustion gases are removed from the unit by means of a turbine driven induced draught fan with a test block rating of 234,600 lb. of flue gas per hour at a static pressure of 2.88" water gauge and a temperature of 615°F. This fan can also be driven by an electric motor when no steam is available.

In order to control and complete combustion overfire, air is supplied to the furnace through ports at two levels at front and rear above the stoker grate. The air for this service is supplied by a turbine driven overfire air blower having a test block rating of 7,500 C.F.M. at 30" water gauge static pressure and a temperature of 105°F. This blower also supplies air to the windswept refuse spouts located at the front of the boiler through which the refuse is distributed evenly into the furnace over the grate.

To increase the thermal efficiency of the unit, and for more complete carbon burn out, cinders collected in the boiler and air heater hoppers are reinjected at the rear of the furnace just over the grate.

For flue gas clean up an electrostatic precipitator has been supplied. The precipitator has been designed to remove 98.5 percent (by weight) of the entering particulate mater and will handle a gas volume of 80,500 CFM at 590°F.

WHEELABRATER LURGI ELECTROSTATIC PRECIPITATOR

1.0 Gas Operating Conditions

1.1	Source	Two (2) 300 ton water wall incinerators
1.2	Quantity	184,200 lb./hr.
1.3	Temperature	590°F
1.4	Pressure	± 20 inches WC (design)
1.5	Dust Content	5.33#/1000# gas at 50% excess air

2.0	Precipitator Data (for one (1) unit, two (2) required)	
2.1	Cross Section	388 ft.^{2}
2.2	Velocity	3.48 f.p.s.
2.3	Treatment time	5.38 secs.
2.4	Gas Passages	18
2.5	Field height	25 ft.
2.6	No. of fields	Two (2)
2.7	Field length	9'-4"
2.8	Collecting area	
2.8.1	Projected	17,500 ft.^{2}
2.8.2	Actual	21,000 ft.^{2}
2.9	Collecting surface	
2.9.1	Type	Pocketed 18 3/4" x 18 ga. x 25 ft.
2.9.2	Material	Cold rolled steel
2.10	Plate Spacing	10" on centers
3.0	Discharge Electrodes	
3.1	Type	Star shaped, .288" diameter in 1" diameter pipe frame.
3.2	Material	Cold rolled mild carbon steel
3.3	Total length of electrodes	16,200
3.4	Supports	8 - fused silica insulators
4.0	Casing	
4.1	Gas distribution devices	3 - 12 ga. perforated plates carbon steel
5.0	Rappers	
5.1	Collecting surface	2 drives 38 hammers
5.2	Discharge electrode	2 drives 36 hammers

6.0 Electrical

6.1	High voltage sets	Full wave (double half wave not required)
6.2	Type	Silicon diode rectifier
6.3	Number & Size	2 - 500ma, 45 kV
6.4	Transformer coolant	Askarel or Pyranol
6.5	Power supply	550 volt, 60 cycle, 3 phase
6.6	Power consumption (precip., insulator heaters & rappers)	34.4 KW
6.7	Rectifier rating	70 KVA
6.8	High voltage conductor	2
6.9	Automatic power control	2
6.10	Rapper Control	1 cabinet with 2 timers Eagle Flexopulse repeat cycle timer adjustable from 2-40 secs. operating, 10-300 minute interval.

PERFORMANCE GUARANTEE

When operating with an inlet dust loading of 5.33#/1000# gas with 50 percent excess air and a gas volume of 81,000 actual cubic feet per minute at 590°F. the collection efficiency is guaranteed to be 98.5 percent resulting in a dust loading at the precipitator outlet of 0.08#/1000# gas at 50 percent excess air.

APPENDIX 2

REFUSE SAMPLING TECHNIQUE

HAMILTON WENTWORTH REFUSE FACILITY

TESTING PROGRAM

REFUSE SAMPLING TECHNIQUE

EQUIPMENT

15 - Plastic Garbage Cans

1 - Platform Scale, 500 lb.

1 - Camera

4 - Pair Gloves

2 - Clip Boards

1 - Notebook with Sampling Forms

1 - Plastic Sheet

1 - 20 lb. Capacity Scale

COMPONENT ANALYSIS

Clear a portion of the tipping apron of all materials to ensure that all components of each sample will be captured. Arrange a portable 500 pound capacity platform scale and 12 separate, labeled containers on the working surface. Two persons shall be assigned to separating the sample with a supervisor assigned to selection of the sample and assisting in weighing of containers.

The sample shall be a representative portion selected from a typical load or loads with a front loader. Sample size shall be 300 to 400 pounds, or about 1-1/2 to 2 yards. Samples shall be taken from typical loads throughout the test period.

A representative portion is defined as that portion of the load containing all the material contained in the whole load in approximately the same proportions as the whole load. The truck driver of the load from which the sample is removed will be interviewed, using the "truck interview form". This will provide a history of each sample.

Small quantities of mixed waste will be sorted by each sampler and placed in the appropriate containers. This will continue until the entire portion has been sorted. The empty (tare) weights of each container will be recorded prior to sampling. As each container becomes full, it will be weighed, the full (gross) weight of the container recorded on the "refuse sampling form" and the container emptied to one side.

Any container not completely full of refuse at the end of a sample will have the actual volume of refuse measured and recorded on the "refuse sampling form". In this way a volume of loose refuse for each category will be obtained, along with the total net weight.

Photographs will be taken by the field sampling team to record the visual characteristics of each sample. Any information pertinent to the sampling procedure or data reduction will be noted on the "refuse sampling form", including weather conditions, change in moisture content during sampling, and unusual amounts of various items found in the load.

Each load will be separated into the 4 constituent categories, listed below:

1. Paper products, wood products and textiles.

2. Plastics, rubber and leather products.

3. Food and gardening wastes.

4. Ferrous metal, non-ferrous metal and glass products.

At the completion of each day's sampling effort, the work area will be maintained in accordance with the plant's instructions. Each day's completed "refuse sampling forms" will be placed in the field notebook with the matching "truck interview form" for later compilation.

DENSITY

Select six samples from the same load which is sampled for components for field density measurements. Use plastic garbage cans which have been weighed for tare weight and filled with water and weighed for volume determination. Refuse should be loaded into the containers by hand to obtain a relatively undisturbed sample. Weigh each container separately.

PREPARATION OF LABORATORY SAMPLES

The wet weight percentages of each category and component recorded on the form are used to reconstitute a laboratory sample of 20 pounds total weight consisting of two subsamples. A subsample is prepared from the three combustible components based upon their percentages by weight. The wet percentages of the laboratory subsample should be calculated and entered on the laboratory sample form. The wet percentages of the

laboratory subsample should closely agree with the wet percentages of the field sample, although precise agreement will probably not be possible. Major deviations between these values must be explained. The reconstituted subsample is placed in a plastic bag, which is tightly knotted, and this bag is placed in a second plastic bag, which is also tightly knotted, for return to the laboratory for detailed analysis.

A subsample is prepared from the noncombustible components, sealed in a plastic bag, placed in the same larger bag with the combustible subsample, and returned to the laboratory for detailed analyses.

APPENDIX 3

FIELD DATA FORMS

CH2M HILL

TRUCK INTERVIEW FORM

DATE:	TIME:
TRUCK LICENSE NO.:	CITY LICENSE NO.:
TARE WEIGHT:	ACTUAL CUBIC YARDS:
BODY MAKE:	RATED COMPACTION:

GEOGRAPHIC AREA:

TYPES OF SOURCES COLLECTED FROM:

- ☐ RESIDENTIAL
- ☐ APARTMENT
- ☐ COMMERCIAL
- ☐ INDUSTRIAL, specifically _____

BODY TYPE:

- ☐ FRONT-END LOADER
- ☐ BACK-END LOADER
- ☐ SIDE-LOADER
- ☐ NON-COMPACTION DEBRIS BOX
- ☐ COMPACTION DEBRIS BOX
- ☐ DUMP TRUCK
- ☐ STAKE TRUCK

REMARKS:

HAMILTON WENTWORTH REFUSE FACILITY

REFUSE INPUT MEASUREMENT

DATE

START TIME

COMPLETE TIME

IME	TRUCK IDENTIFICATION	WEIGHT

TIME	TRUCK IDENTIFICATION	WEIGHT

FERROUS METALS MEASUREMENT

TIME	VOLUME	WEIGHT

PICKED MATERIAL MEASUREMENT

TIME	VOLUME	WEIGHT

CH2M HILL

INCOMING SOLID WASTE COMPOSITION DATA
LABORATORY SAMPLE

PLANT	DATE
SAMPLE NO.	TIME
	RECORDED BY

COMPONENT	% OF SAMPLE	WEIGHT
COMBUSTIBLES		
All Paper Products, Wood Products, Textiles		
Plastics		
Rubber and Leather Products		
Food and Gardening Wastes		
NONCOMBUSTIBLES		
Ferrous Metals		
Aluminum		
Other Nonferrous Metals		
Glass		
Remaining Inerts		
TOTAL SAMPLE		

CH2M HILL

REFUSE SAMPLING FORM

ATE:	TIME:
UCK LICENSE NO.:	CITY LICENSE NO.:

CATEGORY	TARE WEIGHTS	GROSS WEIGHTS	TOTAL NET WEIGHTS
l Paper Products, od Products, xtiles			
astics			
bber and Leather oducts			
od and Gardening stes			
rrous Metals			
uminum			
her Nonferrous tals			
ass			
maining Inerts			

EMARKS:

CH2M HILL

HAMILTON WENTWORTH REFUSE FACILITY
DENSITY MEASUREMENTS

DATE	RECORDED BY

MATERIAL MEASURED	VOLUME FT^3	WEIGHT LB	DENSITY LB/FT^3	REMARKS

CH2M HILL

HAMILTON WENTWORTH REFUSE FACILITY
ASH MEASUREMENTS

DATE	RECORDED BY

BOILER GRATE ASH

TIME	VOLUME	WEIGHT	REMARKS

PRECIPITATOR ASH

TIME	VOLUME	WEIGHT	REMARKS

APPENDIX 4

ASH COMPOSITION AND LEACHATE ANALYSIS METHODS

TEST PROCEDURES
ASH AND LEACHATE ANALYSES
HAMILTON, ONTARIO, MUNICIPAL RESIDUE
INCINERATOR TEST PROJECT

1. Ash Sampling. A composite sample will be obtained of both incinerator and fly ash during each day of the six day stack emission testing period. The ash samples will be collected at the last point prior to leaving the incinerator site for disposal. The basic sampling unit will be two cubic feet of incinerator ash per day with the fly ash collected proportional to incinerator ash generation. (i.e., if incinerator ash is generated at a rate of ten to one fly ash, then 0.2 cubic feet of fly ash will be collected per day).

a. Sample Containers. Daily samples will be sealed in 6 mil polyethylene bags contained in 20 gallon metal barrels. The incinerator and fly ash samples will be packaged separately to be composited upon arrival at the Eureka laboratory facilities of Winzler and Kelly Laboratories.

b. Ash Sample Analysis. The following analyses shall be performed on each of the composited daily ash samples:

	Parameter	Test Method
1.	Fusion Temperature	ASTM D1857
2.	Density	CalTrans Test Method 231-F (Nuclear Gauge) Performed on Site
3.	Size Distribution	Mechanical/Optional
4.	Resistivity	Resistometer to be Performed on site

5. Ash Chemical Composition.

Parameter	Test Method	Reference
Aluminum	AAS	SMWW-14*, EPA*
Arsenic	AAS	SMWW-14 , EPA
Barium	AAS	SMWW-14 , EPA
Cadmium	AAS	SMWW-14 , EPA

Parameter	Test Method	Reference
Calcium	EDTA	SMWW-14 , EPA
Chloride	Potentiometric	SMWW-14 , EPA
Chromium	AAS	SMWW-14 , EPA
Copper	AAS	SMWW-14 , EPA
Fluoride	SPADNS	SMWW-14 , EPA
Iron	AAS	SMWW-14 , EPA
Lead	AAS	SMWW-14 , EPA
Magnesium	AAS	SMWW-14 , EPA
Manganese	AAS	SMWW-14 , EPA
Mercury	Cold Vapor AAS	SMWW-14 , EPA
Nickel	AAS	SMWW-14 , EPA
Phosphorous	Colorimetric	SMWW-14 , EPA
Potassium	Flame Emission	SMWW-14 , EPA
Selenium	AAS	SMWW-14 , EPA
Silicon	AAS	SMWW-14 , EPA
Silver	AAS	SMWW-14 , EPA
Sodium	Flame Emission	SMWW-14 , EPA
Tin	AAS	SMWW-14 , EPA
Titanium	AAS	SMWW-14 , EPA
Zinc	AAS	SMWW-14 , EPA
Sulfur	Oxidation	"Soil Chemical Analysis", Chem Ash Co., N.Y., N.Y. 1972

* Standard Methods for the Examination of Water and Wastewater, 14th edition.

** Methods for Analytical Analysis of Water and Wastes, MDQARL, NERC, Cincinnati, Ohio.

6. Leachate Analyses. Two basic methods will be utilized for determining the leachate characteristics of the ash. The first procedure will be after the method proposed by Doctor Robert D. Stephens in his memorandum of 2 August 1976 to Mr. Lawrence A. Burch which is essentially a water extraction technique. This extraction will be performed on the daily composite samples and upon a composited six day sample. The second procedure will be to generate leachate from modeled landfill conditions. In this procedure a series of columns containing soil, ash, and ash and soil combinations will be subjected to simulated rainfall with the resultant leachate analyzed for the parameters of interest.

a. Water Extraction Procedure. One to five grams of each ash sample will be extracted per liter of distilled water buffered to a pH of 5 with a phosphate buffer solution ($H_2PO_4 - KH_2 - PO_4$), for

a period of three days. The extractions will be mechanically mixed and the temperature maintained at 24°C. Following extraction the mixture will be filtered through a 0.45μ filter to remove all suspended material. The following tests will be performed on the filtrate:

Parameter	Method	Reference
pH	Electrode	SMWW-14
COD	Dichtromate reflux	SMWW-14
BOD	5 day Incubation	SMWW-14
Aluminum	AAS	SMWW-14, EPA
Arsenic	AAS	
Barium	AAS	SMWW-14, EPA
Cadmium	AAS	SMWW-14, EPA
Calcium	EDTA	SMWW-14, EPA
Chromium	AAS	SMWW-14, EPA
Copper	AAS	SMWW-14, EPA
Iron	AAS	SMWW-14, EPA
Lead	AAS	SMWW-14, EPA
Magnesium	AAS	SMWW-14, EPA
Manganese	AAS	SMWW-14, EPA
Mercury	Cold Vapor AAS	SMWW-14, EPA
Nickel	AAS	SMWW-14, EPA
Potassium	Flame Emission	SMWW-14, EPA
Selenium	AAS	SMWW-14, EPA
Silicon	AAS	SMWW-14, EPA
Silver	AAS	SMWW-14, EPA
Tin	AAS	SMWW-14, EPA
Titanium	AAS	SMWW-14, EPA
Zinc	AAS	SMWW-14, EPA
Chloride	Potentiometric	SMWW-14
Fluoride	Distillation/ SPADNS	SMWW-14
Sulfate	Turbidimetric	SMWW-14
Hydrocarbons	Freon-Silica gel extraction	SMWW-14
Nitrate-N	Brucine	SMWW-14
Total Filterable	180°C	SMWW-14
Bioassay (TL50)	96 Hour, Rainbow Trout	California DF&G

b. Chlorinated Hydrocarbons. The analysis for chlorinated hydrocarbons will be performed on the composited six day sample. If it is determined that chlorinated hydrocarbons are present an additional test will be conducted on a water extracted six day composite sample as described above. Procedures for performing the analyses will be in accordance with the following references:

"Methods for Organic Pesticides in Water and Wastewater," NERC, EPA, 1971.

"Guidelines on Analytical Methodology for Pesticide Residue Monitoring," Federal Working Group on Pest Management, Washington, D.C., June 1975.

"Preliminary Sampling and Analytical Procedures for Evaluating the Disposal of Dredged Materials," Laboratory Support Branch, EPA, Region IX, April 1974.

"Pesticide Analytical Manual," Food and Drug Administration, U.S. Department of Health, Education, and Welfare.

Standard Methods for the Examination of Water and Wastewater-14.

The following compounds will be analyzed for:

Aldrin	Dieldrin
BHC	Endrin
Chlorathane	Endopalfan
DDD (TDE)	Heptachlor
DDE	Heptachlor Epoxide
DDT	Lindane
Dicamba (Banvel)	Methoxychlor
2,4,-D	Mirex
2,4,5-T	PCB
2,4,5-TP (Silvex)	Strobane
	Toxaphene

c. Modeled Landfill Leachate. Landfill conditions will be simulated and leachate generated under modeled conditions which closely proximate those conditions which will actually be encountered during a full scale landfill operation for the disposal of municipal incinerator residues. Those conditions will be simulated by constructing a series of columns containing soil, ash, and ash and soil mixtures and then applying distilled water modeled to simulate three average annual rainfalls.

1. Simulated Landfill Columns. Five conditions will be modeled utilizing the columns, as follows:

   a. Soil Control Column (Site 4)*. This column will contain only soil from site 4 to serve as a blank to determine the leaching characteristics of the disposal site soil. The soil will be compacted to a depth of 12 inches which will be equivalent to six feet of soil cover.

   b. Soil Control Column (Site 8)*. This column will contain only soil from site 8 to serve as a blank to determine the leaching characteristics of the disposal site soil. The soil will be compacted to a depth of 12 inches which will be equivalent to six feet of soil cover.

*Sites 4 and 8 are possible landfill locations designated in the "Solid Waste Resource Recovery System" report of March 1976 by Garretson, Elmendorf, Zinov and Reibin Architects and Engineers, San Francisco, California, and suggested by the State Water Resources Control Board as being "possibly suitable," incinerator residue disposal site.

   c. Ash Control Column. This column will contain ash and will be used to determine the leaching characteristics of the ash without any soil interaction. The column will contain ash compacted to a depth of 20 inches which will correspond to a cell depth of ten feet under actual landfill conditions.

   d. Soil-Ash-Soil Column (Site 4). This column will simulate landfill conditions. The column will contain three layers consisting of six inches of compacted soil overlain by 20 inches of compacted ash, which in turn will be covered by another six inches of compacted soil. The soil will be obtained from site 4 to approximate conditions which may be expected at that location. Compaction of the soil and ash layers will be accomplished to approximate those compaction values which may be expected at the landfill site. The modeled cell column will represent three feet of soil covered by an ash disposal cell of 10 feet depth with three feet of cover soil over the ash cell.

e. Soil-Ash-Soil Column (Site 8). This column will be constructed in an identical fashion as column four using soil from Site 8.

2. Rainfall Application. The average annual rainfall measured at Eureka is approximately 39 inches per year; however, allowing for orographic effects the average annual rainfall at sites 4 and 8 is approximately 50 inches per year (California Department of Water Resources Bulletin No. 142-1). Using the modeling scale of the soil-ash columns and considering the diameter of the columns (6 inches), the equivalent annual precipitation would be:

$$\frac{\text{(Scale depth)}}{\text{(Actual Depth)}} \times \text{(actual rainfall)} = \text{equivalent rainfall}$$

$$\left(\frac{2}{12}\right) \quad (50 \text{ inches}) = 8.33 \text{ inches equivalent rainfall}$$

Accounting for the area of the ash-soil columns, the equivalent rainfall volume will amount to 3.9 liters of distilled water. The volume of leachate produced will be monitored daily with the leachate production volume used to scale the annual time period. A total of three equivalent annual rainfalls will be applied to each column.

The following analysis will be conducted on the leachate generated from each column:

Parameter	Method	Reference
pH	Electrode	SMWW-14
COD	Dichromate Reflux	SMWW-14
BOD	5 Day Incubation	SMWW-14
Aluminum	AAS	SMWW-14
Arsenic	AAS	SMWW-14
Barium	AAS	SMWW-14, EPA
Cadmium	AAS	SMWW-14, EPA
Calcium	EDTA	SMWW-14, EPA
Chromium	AAS	SMWW-14, EPA
Copper	AAS	SMWW-14, EPA
Iron	AAS	SMWW-14, EPA
Lead	AAS	SMWW-14, EPA
Magnesium	AAS	SMWW-14, EPA
Manganese	AAS	SMWW-14, EPA
Mercury	Cold Vapor AAS	SMWW-14, EPA
Nickel	AAS	SMWW-14, EPA
Potassium	Flame Emission	SMWW-14, EPA
Selenium	AAS	SMWW-14, EPA
Silicon	AAS	SMWW-14, EPA
Tin	AAS	SMWW-14, EPA
Zinc	AAS	SMWW-14, EPA

Parameter	Method	Reference
Chloride	Potentiometric	SMWW-14, EPA
Fluoride	Distillation/SPADNS	SMWW-14, EPA
Sulfate	Turbidimetric	SMWW-14, EPA
Alkalinity	pH - Titration	SMWW-14, EPA
Hydrocarbons	Freon-Silica gel	SMWW-14, EPA
Nitrate - N	Brucine	SMWW-14, EPA
Nitrite - N	Colorimetric	SMWW-14, EPA
Phosphates	Colorimetric	SMWW-14, EPA
Total Dissolved Solids	180°C	SMWW-14, EPA

APPENDIX 5

SAMPLING & ANALYTICAL PROCEDURES

PARAMETER	SAMPLING & ANALYTICAL TECHNIQUE	RESPONSIBILITY	REMARKS
STACK EMISSIONS			
TEMPERATURE	Thermocouple	EPA and OME	
GAS FLOW	EPA Method 1 and OME Test Code	EPA and OME	
MOISTURE	EPA Method 4 and OME Test Code	EPA and OME	
PARTICULATES			
• Precipitator Inlet Mass Loading	SLM Sampler Method	B & W	Filter in Stack Method
• Stack Discharge Modified Mass Loading	Modified EPA* Method 5	EPA and OME	6 Samples
• Particle Sizing			
○ Inlet	Cascade Impactor	B & W	
○ Outlet	Brinks Impactor	EPA	
• Opacity	EPA Method 9, Visual	Humbolt Cnty/CH2M HILL	
• Composition	Mass Spectroscopy	Humbolt Cnty/CH2M HILL	
• Resistivity	ASME Power Test Code No. 28	B&W and EPA	Run on precipitator inlet particulate
GASES			
• Carbon Monoxide	EPA Method 3,/ORSAT Analysis	EPA and OME	
• Carbon Dioxide	EPA Method 3,/ORSAT Analysis	EPA and OME	
• Oxygen	EPA Method 3,/ORSAT Analysis	EPA and OME	
• Nitrogen	EPA Method 3,/ORSAT Analysis	EPA and OME	
• SO_2	EPA Method 6	Humbolt Cnty/ORF	3 Samples
• NOx	Continuous Monitor Teco Chemiluminescent Monitor	Humbolt Cnty/ORF	3 Hours continuous sample
• Chlorides	LA/APCD Method Water and Caustic in Impingers	Humbolt Cnty/ORF	3 Samples
• Total Hydrocarbons	Continuous Monitor – IPM Model RS5	Humbolt Cnty/ORF	3 Hours continuous sample
• Polynuclear Hydrocarbons (Benzopyrene)	Extraction from Particulate Test for PCB's plus Absorbant Tubes	OME	3 Samples
• Polychlorinated Biphenols (PCB'S)	EPA Method 5 w/ethylene Glychol in Impingers	OME	3 Samples
• Organic Acids	LA/APCD Method, Na OH Soln in Impingers	Humbolt Cnty/ORF	3 Samples
• Aldehydes –Total Carbonyls	LA/APCD Method, Na H SO_3 Soln in Impingers	Humbolt Cnty/ORF	3 Samples
• Mercury	Tentative E.P.S. Procedure Acidified $KMnO_4$	Humbolt Cnty/ORF	3 Samples
• Carcinogenic Organics	Mutox Screening, Impinger Train w/Hexane	Humbolt Cnty/CH2M HILL	3 Samples + 1 Blank

PARAMETER	SAMPLING & ANALYTICAL TECHNIQUE	RESPONSIBILITY	REMARKS
FUEL SAMPLES			
BOILER INPUT	Truck Scales at Plant	Humbolt Cnty/CH2M HILL	Delivered material less metals
PHYSICAL COMPOSITION	Separate as Delivered Material	Humbolt Cnty/CH2M HILL	4-300 lb samples daily
DENSITY	Bulk Density — as Delivered and Shredded	Humbolt Cnty/CH2M HILL	Done in field
SIZE DISTRIBUTION	E11 Sieves Std — as Delivered and Shredded	Humbolt Cnty/CH2M HILL	Done in field
HEATING VALUE	Calculated from Composition	Humbolt Cnty/CH2M HILL	
PROXIMATE ANALYSIS	ASTM D 3172	Humbolt Cnty/CH2M HILL	3-20 lb samples shipped to lab
• Moisture	ASTM D 3173		
• Volatile Matter	ASTM D 3175		
• Fixed Carbon	Calculation		
• Ash	ASTM D 3174		
ULTIMATE ANALYSIS	ASTM D 3176	Humbolt Cnty/CH2M HILL	3-20 lb samples shipped to lab
• Carbon	ASTM D 3178		
• Hydrogen	ASTM D 3178		
• Nitrogen	ASTM D 3179		
• Sulfur	ASTM D 3177		
• Fluorides	ASTM D 3270		
• Chlorides	ASTM D 2361		
• Silicon	AAS of Ash		
• Metals	EM SPEC and AAS		
• Ash	ASTM D 3174		
ASH SAMPLES			
BOILER DISCHARGE	Site Measurement, Volume $Ft.^3$ /Hr	Humbolt Cnty/CH2M HILL	
PRECIPITATOR DISCH.	Site Measurement, Volume $Ft.^3$/Hr	Humbolt Cnty/CH2M HILL	
DENSITY	Bulk Density	Humbolt Cnty/CH2M HILL	Field measurement. Samples shipped to lab, 3-55 gallon drums
SIZE DISTRIBUTION	Optical Microscopy	Humbolt Cnty/W & K	
FUSION TEMPERATURE	ASTM D 1857	Humbolt Cnty/W & K	
RESISTIVITY	Resistometer	Humbolt Cnty/W & K	
CHEMICAL COMP.	ASTM, SMWW 14	Humbolt Cnty/W & K	
• P_2O_5	Colorimetric		
• SiO_2	AAS		
• Al_2O_3	AAS		
• TiO_2	AAS		
• Fe_2O_3	AAS		
• CaO	AAS		
• MgO	AAS		
• K_2O	AAS		
• Na_2O	AAS		

PARAMETER	SAMPLING & ANALYTICAL TECHNIQUE	RESPONSIBILITY	REMARKS
ASH SAMPLES (cont.)			
CHEMICAL COMP. (cont.)			
• SnO	AAS		
• CuO	AAS		
• ZnO	AAS		
• PbO	AAS		
• Other Metals	AAS		
• Sulfur Compounds	Oxidation, Gravimetric		
• Chlorine Compounds	Eschta, Titration		
• Bacteriological Contaminants			
• Polychlorinated Biphenols (PCB'S)		OME	
BOILER OPERATION			
STEAM LOAD	Recorder Charts	B & W	
STEAM PRESSURE		B & W	
STEAM TEMPERATURE		B & W	Will attempt to shut-off during test
CONT. BLOWDOWN		B & W	
GRATE SPEED		B & W	
E.S.P. SETTINGS (Voltage, etc.)		B & W	
LEACHATE ANALYSIS			
pH	SMWW 14	Humbolt Cnty/W & K	From 3 - 55 gallon drum samples shipped to lab
COD	SMWW 14	Humbolt Cnty/W & K	
BOD	SMWW 14	Humbolt Cnty/W & K	
METAL SALTS	SMWW 14	Humbolt Cnty/W & K	
• Chloride	SMWW 14		
• Sulfates	SMWW 14		
• Fluorides	SMWW 14		
ALKALINITY	SMWW 14	Humbolt Cnty/W & K	

HAMILTON WENTWORTH SOLID WASTE REDUCTION FACILITY

PARAMETER	SAMPLING & ANALYTICAL TECHNIQUE	RESPONSIBILITY	REMARKS
LEACHATE ANALYSIS (cont.)			
HYDROCARBONS	SMWW 14	Humbolt Cnty/W & K	
NITRATES	SMWW 14	Humbolt Cnty/W & K	
PHOSPHATES	SMWW 14	Humbolt Cnty/W & K	
TOTAL SOLIDS	SMWW 14	Humbolt Cnty/W & K	

NOTES:

ABBREVIATIONS

EPA	U.S. Environmental Protection Agency
OME	Ontario Ministry of the Environment
B & W	Babcock & Wilcox
W &K	Winzler & Kelly Consultants
SMWW	Standard Methods for the Analysis of Water and Wastewater
AAS	Atomic Absorbtion Spectroscopy
EM SPEC	Emission Spectroscopy
I.R.	Infared Analysis
ORF	Ontarior Research Foundation

*Modified EPA Method 5 includes organic extraction of back-half catch.

APPENDIX 6

DETAILED OPERATING LOG

OPERATING LOG
EAST HAMILTON SWARU TEST
OCTOBER 12-18 1976

DATE	TIME	OPERATING CONDITION	REMARKS
Tuesday 10/12/76	8:30	Refuse delivery started	Dumped into pit
		Boiler up to temperature on gas	
	9:00	Refuse feed begun 3 pulverizers on line	No air flow control - I.D. fan damper stuck
	10:15	Refuse feed system plugged	Boiler back on gas
	10:45	Refuse feed started	
	11:15	Steam load held reasonably constant at 85% load	Lost it after 15 minutes - inconsistent feed
	12:00	Lunch break - boiler operated by plant personnel	
	13:00	Refuse feed plugged	On gas
	13:30	Refuse feed plugged	On gas
	14:00	Refuse feed plugged	On gas
	14:20	Restart refuse	
	14:50	Lost feed	10 minutes
	15:00	Restart refuse	
	15:30	Attempt to operate at about 70% load	Load swings of $\pm$ 20%

		load	
	16:20	Lost feed - partially plugged	Attempted to continue operation at low feed rate
	16:40	Lost feed - chutes plugged	On gas
	17:20	Restart refuse feed	Uneven feed rates
	18:00	Lost feed	Bridge breaker in feed chute stuck
Wednesday 10/13/76	8:30	First refuse truck arrived	166 ton loaded in pit
	9:23	Start refuse feed	Attempted to bring unit up to full load. --Feed variations and minor plugging plagued operation.
	11:00	Lost feed	Bridge breaker stuck on gas
	12:00	Restart refuse feed	1 1/2 hr. operation at 80% Load ± 20%. B&W and EPA doing preliminary measurements.
	13:50	Boiler up to full load	15 minutes - lost feed
	14:05	Lost feed - bridge breakers stopped	Gear box defective. Replacement took just over an hour. Boiler on gas.
	15:20	Restart refuse feed	Boiler brought up to 80% load maintained there ± 20% for 3 1/2 hours. ID fan dampers stuck in open position. Particulate test runs by EPA and B&W. No loss of feed during this period.

	20:00	Boiler shutdown	Out of reuse
Thursday 10/14/76	8:15	Start refuse feed	Boiler up to load 3 times in first hour. Plugged feed each time. Problems with bridge breakers and overfire air turbi drive.
	10:05	Feed chute plugged	On gas. Bridge breaker drives burnt-out. New drives ordered for installation tomorrow morning. System operated at reduced load remainder of day w/o bridge breakers.
	10:50	Restart refuse feed	
	11:05	Lose feed	
	11:15	Restart feed	
	11:40	Lose feed	Plugged chutes
	12:00	Restart feed	
	12:20	Lose feed	Plugged chutes
	12:40	Restart feed	
	12:50	Lose feed	Overfire air turbine drive kicking out
	13:20	Restart feed	Operated @ 50% load for 1 1/2 hours w/o loss of feed. Then a 45% load for one hour. Both at ± 30%. Particulate & gas testing during this period.

		problems with overfire air fan turbine	remainder of the day.
Friday 10/15/76	8:00	Change bridge breaker drives	New gear motors installed with chain drives to bridge breaker sprockets.
	10:45	Start refuse feed	
	11:10	Lost feed	Bridge breakers stuck. Necessa: to cut cleanout holes in chutes
	15:35	Restart refuse	
	16:05	Shut down feed	Fuel piling on grates-overfire air fan turbine kicking out.
	17:00	Similar kick-out problems to previous day with overfire air turbine	No consistent operation the remainder of the day.
Saturday 10/16/76	8:20	Start refuse feed	Continue to have problems with overfire air turbine and settin on stokers. No consistent operation.
	10:40	Refuse feed shut off	Working on overfire air turbine governor.
	11:15	Restart refuse	Still air problems
	11:35	Shut down feed	Replace worn shaft in turbine governor
	13:20	Restart refuse feed	

	13:45	Begin gas sampling	2 hr. run at 70% load 45 minutes @ full load
	17:00	Erratic operation - chute plugging	
	17:05	Gas on	
Sunday 10/17/76	9:40	Start refuse feed	
	10:30	No. 1 pulverizer plugged	Speed up No. 3 & 4
			B&W ran 2 1/2 hr test at 80 to 90% load
	11:40	Slowed conveyors - blowing off safeties.	Lost control of steam load for 30 minutes.
	13:00	Lost refuse feed	Erratic operation for rest of day.
Monday 10/18/76	8:30	Exercise emergency generation	Required weekly - interrupts electrical circuits
	9:30	Start refuse feed	
	10:15	Stop feed	Bridge breaker stuck
	10:35	Restart feed	
	11:40	Stop feed	Bridge breaker
	11:50	Restart feed	
	12:15	Stop feed	Bridge breaker
	12:25	Restart feed	
	12:40	Start B&W test	Average load $\sim$ 75% $\pm$ 20%

13:30	Stopped two pulverizers to clear feed conveyors	Only one left running
13:35	Restart pulverizers	
14:35	Lost smooth feed	
16:05	Plugged No. 1 pulverizer	Shutdown pulverizer for the day. Last hour of test at about 60% load ± 25%.
17:00	Plugged No. 4 pulverizer	Stopped feed - on gas

APPENDIX 7

COOPERATING AGENCY REPORTS

COUNTY OF HUMBOLDT
Inter-Office Memo

DEC 24 1976

PUBLIC WORKS
DIRECTOR
Asst. Director
Engineering
Aviation
Field
Office
Sec. #3 Maint.
Equip. Maint.
Natural Res.
Park & Rec.
Real Prop.
Res. Dist. Ferry
Road Dist.
Solid Waste
Bureau Head
File
Action / Info
Date

December 23, 1976

Guy Kulstad, Director Of Public Works

: C. P. Sassenrath, Air Pollution Control Director

ct: Trip Report - Hamilton, Ontario Emission Testing Critique

ecember 22, 1976, a meeting was held at the Airport Hilton Inn in Francisco to review the results of the emission testing program ucted at the Hamilton, Ontario solid waste disposal plant. Rep- ntatives were present from the Los Angeles, Bay Area and Humboldt ty Air Pollution Control Districts, Air Resources Board, State Solid e Management Board, State Energy Commission, Winzler and Kelly, -Hill, and GEZR.

Wilkerson of Winzler and Kelly and Richard Reid of CH_2M-Hill ribed the operation of the Hamilton solid waste boiler plant during test period of 10/13/76-10/18/76. There was generally very unstable ace operations during the test period caused by poor fuel feed ods, erratic overfire air fan operation, and numerous other plant unctions. The various air contaminant emission test results were vidually discussed.

liculate emission grain loadings which averaged above 0.6 grains per c foot were well above all applicable standards. These excess emiss- were traced to poor condition of the electrostatic precipitator, surging, excess induced draft air flow rate and lack of a precleaner d of the precipitator. It was generally concluded that a large icle precleaner and electrostatic precipitator could be designed to Humboldt County particulate emission standards of 0.1 grains per c foot. Bay Area and Los Angeles APCD representatives were somewhat ommital on their exact emission control requirements.

other air contaminant emissions were below Humboldt County standards.

Hamilton test results have provided sufficient information to proceed the design of an emission collection system for any future solid e refuse burning facilities contemplated for Humboldt County.

C. P. Sassenrath

RECEIVED
DEC 28 1976
WINZLER & KELLY

CALIFORNIA --THE RESOURCES AGENCY
EDMUND G. BROWN JR., Governor
SOLID WASTE MANAGEMENT BOARD
STREET
TO, CALIFORNIA 95814

May 3, 1977

r. William D. Kuntz
umboldt County Public Works Department
1106 Second Street
ureka, CA 95501

ear Bill:

ike Kennedy sent me a copy of the January 1977 redraft of the "analysis of Fuel, Ash, and Flue Gas Characteristics" report. I have quickly reviewed it, with the following comments and observations. In general, the draft report covers the data collection process well, with the data adequately presented. However, I think the report is short on delineating the important findings, conclusions and recommendations which can be drawn from the data. In particular I am looking for conclusions and recommendations as to whether direct fired shredded refuse boilers could and/or should be used in California (Los Angeles, San Francisco, Humboldt, etc.). There is no discussion of the conclusions raised by the panel of experts gathered in San Francisco. Specific comments follow:

1. The summary should include a specific comparison of SOx and Cl collected data vs. literature data for emissions and waste composition. This will give the reader a relative magnitude of the differences.

2. The San Francisco meeting of experts should be detailed, with the consultant's interpretation of the significant points raised and discussed.

3. Table 4 reflects that on Wednesday, 10/13/76, the operation was significantly different from the remaining days:

		WEDNESDAY	OTHER DAYS (ave.)
Ferrous	%	4.0	4.9
Non Ferrous	%	0.6	.0.9
Bottom Ash	%	10.7	20.7
Fly Ash	%	2.3	6.3
Non Combustible	%	18.0	32.8
Steam - lb/ton in	%	3,800	4,600
Steam - lb/combustibles	%	4,600	6,900

4. The ferrous collected represents only a 60% fraction of that available according to the composition sample.

5. Estimated fuel value to boiler in Table 7 should reflect the lower ferrous removal efficiencies as shown in item number 4 above.

6. The samples taken for chemical analysis showed a 45-50 percent moisture content. Does this reflect a sampling procedure which picked out extremely wet, putrescible wastes? Can anaerobic decomposition produce this magnitude of moisture increase?

7. Do the HHV's of Combustion Engineering as presented in Table 7 reflect "in situ" garbage-can/packer-truck moisture conditions, or are they based on dry samples? The composition of Hamilton refuse as sampled probably reflects moisture migration between wet and dry fractions. The average of 5000 BTU/lb compares favorably with heating values used by the SSWMB in its Bay Area study.

8. The calculations of ash on page 24 seem to be awry. The 12 percent ash reflects the ash content of dry organics. The dry organics only represent 57 percent (100%-18% inserts-25% water) of the total. Therefore the ash only represents 7 percent of the total.

9. What impact did the decomposition of the chemical sample have on the Proximate & Ultimate analyses?

On the whole, the report is very informative and will be a useful addition to the data bank on refuse fired boiler air emission characteristics. The consultant did a commendable job under trying conditions.

Sincerely,

John F. Boss
Acting Chief
Resources Utilization Division

cc: Larry Burch

Army Polansky

Mike Kennedy

Duane Heber

Evan Hughes

ALIFORNIA THE RESOURCES AGENCY
SOLID WASTE MANAGEMENT BOARD
STREET
O, CALIFORNIA 95814

EDMUND G. BROWN JR., Governor

May 4, 1977

Mr. William D. Kuntz
Humboldt County Public Works Department
1106 Second Street
Eureka, CA 95501

Dear Bill:

Attached are written comments from Gil Torres and Tom Dunbar on the Hamilton, Ontario ash residue and leachate analysis. Due to extended field work Tom could not get his comments down in writing until just recently. From these comments and the discussion at the March 30, 1977 meeting the following conclusions seem to be evident:

1. The ash residue produces a leachate of the quality and character which must be prevented from entering surface or ground water streams. This means containment at the landfill and treatment of the effluent.

2. A leachate treatment scheme such as presented by CH_2M-Hill might be adequate for this type of residue.

3. Humboldt County will have to open a new Class II-1 site in any case, whether energy conversion is practiced or not.

4. The chemical analysis of the ash residue provided data which led State Department of Health to preliminarily classify the ash as a hazardous waste. This might make this material subject to the State Department of Health's $1.00/ton surcharge.

5. The test data was not sufficient to warrant a "no/go" decision on the project. However, the increased residue treatment requirements will have to be considered in the economic analysis.

Please have Winzler & Kelly/CH_2M-Hill incorporate these comments into their final report on environmental testing.

Sincerely,

Original Signed By
John F. Boss (mc)

John F. Boss
Acting Chief
Resource Utilization Section

Attachment

cc: Individuals on attached list

Mr. John Boss
Solid Waste Management Board
1709 11th Street
Sacramento, CA 95814

Date: APR 4 1977

In Reply Refer
To: 415:GT

STATE WATER RESOURCES CONTROL BOARD
DIVISION OF PLANNING AND RESEARCH

Humboldt County Resource Recovery Project

This is in reference to the March 30, 1977, meeting in Berkeley pertaining to the ash and leachate analysis results for the Hamilton-Ontario refuse combustion test.

In view of the data presented by Winzler and Kelly, it is evident that the 140 to 150 tons of incinerator ash to be disposed daily should be exported to an approved Class I site. It is my understanding that geotechnical and/or hydrogeologic studies are currently being conducted to evaluate the Class II-1 disposal potential of sites in the Humboldt County area. Any decision concerning the ultimate disposition of the Group 1 ash wastes should be subject to the findings, conclusions, and recommendations of that ongoing technical assessment.

GIL TORRES
Associate Engineering Geologist

cc: Mr. Tom Dunbar
California Regional Water
Quality Control Board,
North Coast Region
1000 Coddingtown Center
Santa Rosa, CA 95401

of California

The Resources Agency of California

memorandum

: Solid Waste Management Board
1416 Ninth Street, Room 1335
Sacramento, California 95814

Date : May 2, 1977

Attn: John Boss

: California Regional Water Quality Control Board
North Coast Region - Suite F, 2200 County Center Drive
Santa Rosa, California 95401

I have recently reviewed a copy of Winzler and Kelly's February 1977 report entitled Municipal Incinerator Residue Ash and Leachate Analysis. The following are my comments concerning this report and landfill requirements for ash.

Three different methods were utilized to better quantify mineral constituent concentrations in ash leachate -- complete digestion, water extraction, and leaching columns. Complete digestion was conducted in order to determine what minerals and chlorinated hydrocarbons are present in the ash and in what quantities. The results of four different samples are very consistent and support the general belief that high concentrations of a wide variety of minerals are present in the ash. While this information is a valuable measure of the total potential for impacts on water quality it does not reveal actual characteristics of leachate that may be generated at a landfill. Therefore, I have no specific comments to offer concerning the results of this analysis.

The water extraction analysis attempted to show what quantity of minerals could be dissolved from a given amount of ash. These tests were conducted on solutions made from five grams of ash per liter of buffered water. All parameters have extremely low concentrations and cause no toxic effects on rainbow trout. A fourth test with forty grams of ash per liter of unbuffered water produced higher constituent concentrations in general than each of the five grams per liter solutions and was toxic to trout. Specific comparisons of constituents cannot be made due to small sample quantities, apparent nonhomogeneity of the ash, and the resultant fluctuation of concentrations as shown in Table IV.

The leachate column tests on the other hand each utilized thirty pounds of ash, which greatly reduces the question of homogeneity. The results are quite comparable in all three tests as reported in Tables VII, VIII, and IX. Soil at the top and bottom of two of the columns apparently reduced the pH and the alkalinity of the leachate thus releasing more of the calcium, potassium, magnesium, manganese, and sulfate ions. The increased release of these ions was probably caused by the acidic water from the top layer of soil. The bottom layer of soil maintained the acidic condition and permitted passage of the ions out of the column with little or no ion exchange in the soil.

The importance of these results is the proof that incinerator residue from refuse derived fuel contains high concentrations of soluble minerals. The minerals are readily soluble in that they do not require microbial breakdown in order to be released into the leachate; breakdown occurred during incineration. Because of the high solubility and potential for impact on water quality, State regulations require that municipal incinerator residue be disposed of in a Class I disposal site.

I believe that a large landfill used for municipal solid wastes over several years has the same potential for water quality degradation whether the wastes are incinerated or not. Many leachate samples that I have collected at landfills where wastes are not incinerated show much the same characteristics as that described in the Winzler and Kelly report. In a high rainfall area such as the north coast of California any large landfill for municipal solid wastes should have special design characteristics to protect water quality. Of course, Class I, II-1, and II-2 requirements for a landfill are based on many factors, and with the right combination of factors incinerator residue from refuse derived fuel could be disposed of in any of these site classes instead of Class I only.

Thank you for the opportunity to comment on this report. If you desire further comment, please feel free to ask.

Sincerely,

Thomas B. Dunbar

Thomas B. Dunbar
Associate Water Resources Control Engineer